Development and Spread of HIGH-YIELDING VARIETIES OF WHEAT AND RICE in the Less Developed Nations

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ABSTRACT

The use of high-yielding varieties (HYV's) of wheat and rice has expanded sharply in the developing nations in recent years. This report reviews the development of these varieties and documents their yearly spread in statistical terms. Major emphasis is placed on semi-dwarf (1) wheat varieties developed at the International Maize and Wheat Improvement Center (CIMMYT) in Mexico, and (2) rice varieties developed in the Philippines at the International Rice Research Institute (IRRI). Semi-dwarf varieties developed in national breeding programs are also included.

Data cover the 10-year period from the 1965/66 crop year, when these varieties first came into wide use, through 1974/75. As of 1974/75, the HYV wheat and rice area in non-Communist nations in Asia and the Near East (including North Africa), totaled about 40.9 million hectares (101 million acres). Of this, about 19.3 million ha. (47.7 million acres) were wheat and 21.6 million ha. (53.3 million acres) were rice. In addition, several million ha. of HYV wheat and about 770,000 ha. (1.9 million acres) of rice were planted in Latin America (excluding Cuba). The HYV area in Africa was relatively minor.

Within Asia and the Near East in 1974/75, most of the HYV wheat area and nearly all of the HYV rice area was found in Asia. Over half of the HYV area of both wheat and rice was in India. India was followed by Pakistan in the case of wheat and Indonesia and the Philippines in the case of rice. Altogether, the HYV's accounted for about 38.4 percent of the total wheat area and 26.0 percent of the total rice area in Asia and the Near East.

KEY WORDS: Wheat, rice, green revolution, high-yielding varieties, seed, research, agricultural development, developing countries.

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PREFACE

This bulletin represents the fifth edition of this report. The preceding edition was issued in July 1974 under the same title, while earlier editions, titled *Imports and Plantings of High-Yielding Varieties of Wheat and Rice in Less Developed Nations*, were issued in February 1972, January 1971, and November 1969. All are supplanted by this edition.

In this edition the material has been updated through 1974/75 and several changes have been made:

- Chapter I has been rewritten to include more precise varietal definitions.
- In Chapter II, the portion on the origin of high-yielding wheat varieties has been expanded.
- In Chapters III and IV, a section on the Near East has been added, including West Asia and North Africa. Within each chapter, the coverage of high-yielding varieties in Africa and Latin America has been expanded considerably.
- In Chapter III, material has been included on rice improvement in Communist nations which was formerly contained in the Appendix.

The statistical portion of this report focuses on the 10 crop years from 1965/66 to 1974/75, a period that might be called the first decade of the "green revolution." Some fragmentary preliminary estimates are included for 1975/76. Data reported are based on information in hand as of April 1976.

As in the past, many individuals and organizations have cooperated generously in the preparation of the report. Among the individuals, I would particularly like to acknowledge the many contributions of Dr. R. Glenn Anderson of the International Maize and Wheat Improvement Center (CIMMYT) and Dr. T. T. Chang of the International Rice Research Institute (IRRI). Collection of country data was largely made possible through the assistance of agricultural attachés of the U.S. Department of Agriculture (USDA) and food and agriculture officers of the Agency for International Development (AID). I am also indebted to scientists from the Agricultural Research Service, USDA, and staff members of the Ford Foundation, the Rockefeller Foundation, and the Food and Agriculture Organization of the United Nations (FAO).

FAO plans to publish some similar, but more comprehensive, area data for several grains in the near future. A review of the preliminary FAO data suggests the use of a broader definition of high-yielding varieties than is utilized here. This report, as will be noted, is largely limited to semi-dwarf varieties.

While an attempt has been made to make the report as accurate as possible, some errors have undoubtedly gone undetected. I bear the responsibility.

Funding for this project was, as in the past, provided through the Office of Agriculture, Technical Assistance Bureau, AID. Some work was done on this project while I was on part-time detail to the Bureau for Program and Policy Coordination, AID.

CONTENTS

Conversion Factors

1 hectare (ha.) = 2.471 acres
1 acre = 0.4047 hectare (ha.)
1 meter (m.) = 39.37 inches
1 centimeter (cm.) = 0.3937 inches
1 metric ton (M.T.) = 2,204.6 pounds
1 kilogram (kg.) = 2.2046 pounds

Table Key

NA = data not available
— = zero or virtually zero
negl. = negligible
prelim. = preliminary

SUMMARY

High-yielding varieties (HYV's) of wheat and rice have formed the core of what is popularly known as the "green revolution." This report summarizes historical information concerning their development and statistical data relating to their spread for the 10-year period from 1965/66 to 1974/75.

Emphasis is placed on semi-dwarf varieties developed at what is now the International Maize and Wheat Improvement Center (CIMMYT) in Mexico and the International Rice Research Institute (IRRI) in the Philippines since the early 1960's. Some of the current semi-dwarf HYV's, however, are the offspring of varieties developed from similar ancestors in other breeding programs. The relatively short, stiff stalk of the semi-dwarfs means that they respond to improved cultural practices through increased yields rather than through increased plant growth which would also result in lodging (falling over of the plant).

The semi-dwarf HYV's in current use, while considered by some to be revolutionary in their impact, are the product of a long evolutionary and development process.

Semi-dwarf wheats were noticed in Japan in the 1800's. Early in the 20th century, several of these varieties found their way to Italy where they were used to breed improved varieties which later found wide use. Japanese breeders also crossed their varieties with several American types, ultimately resulting in the release of a Norin variety in 1935. It was brought to the United States in 1946, again crossed with some American varieties, and taken to Mexico in the early 1950's. There the Norin-Brevor cross, in addition to some of Italian varieties, was used by Dr. Norman Borlaug and his associates to develop the well-known Mexican varieties.

Early-maturing rice varieties were known in China as early as 1000 A.D. The present IRRI varieties appear to have originated, at least in part, in China, Taiwan, and Indonesia. The common ancestor of the current IRRI varieties is Peta, which originated from a cross made between Chinese and Bangladesh varieties in Indonesia in 1941. The semi-dwarf parent of the IRRI varieties is thought to have gone from China to Taiwan several hundred years ago. The first widely adapted IRRI variety, IR-8, was released in November 1966. Ten other varieties have subsequently been released, the most recent in July 1975. The newer varieties are being bred for improved resistance to insects and diseases as well as greater tolerance to climatic stresses.

In focusing on semi-dwarf HYV's coming into widespread use since the mid-1960's, the report does not cover earlier waves of improved varieties. The most obvious is the initial use of improved (but not semi-dwarf) wheat varieties in Mexico itself; by the late 1950's, over 90 percent of the Mexican wheat area was planted to such varieties. These early varieties were later replaced by the semi-dwarfs, but we have no statistical record of this

process. Similarly, Taiwan has a long history of improved rice varieties; none are included here. On the other hand, some improved varieties which are not semi-dwarfs have occasionally been included because it has not been possible to sort them out from available statistics.

Most of the data reported are for Asia (South and East) and the Near East (West Asia and North Africa). Data for HYV's in Africa and Latin America are skimpy, but some estimates are presented. For Asia and the Near East, HYV wheat data are provided for 19 countries and HYV rice data for 15 countries. Communist nations are excluded from the statistics (except for South Vietnam), but some information is provided on HYV use; developed countries are also excluded.

Despite the data limitations, some trends are clear. In Asia and the Near East, the area of both HYV wheat and HYV rice continued to rise in 1973/74 and in 1974/75. The total area of HYV's of both crops was about 37.9 million ha. (93.7 million acres) in 1973/74, and 40.9 million ha. (101.0 million acres) in 1974/75. Of the 1974/75 total, about 47.2 percent or 19.3 million ha. (47.7 million acres) was composed of wheat, and about 52.8 percent or 21.6 million ha. (53.3 million acres) were planted to rice. In 1974/75, the rate of increase in the overall HYV wheat and rice area dropped off somewhat in Asia. In terms of individual countries, the major drops were: wheat, Egypt and Morocco; rice, Bangladesh, Pakistan, and Sri Lanka. Given the fertilizer crisis of the period, this drop was not surprising—in fact, a greater drop might have been expected.

The HYV's represented the following proportions of total wheat and rice area in all non-Communist LDC's in the two regions in 1974/75:

Region	Wheat	Rice
	Percent	
Asia (South & East)*	61.7	26.4
Near East (West Asia & North Africa)	14.3	1.8
Total Asia & Near East	38.4	26.0

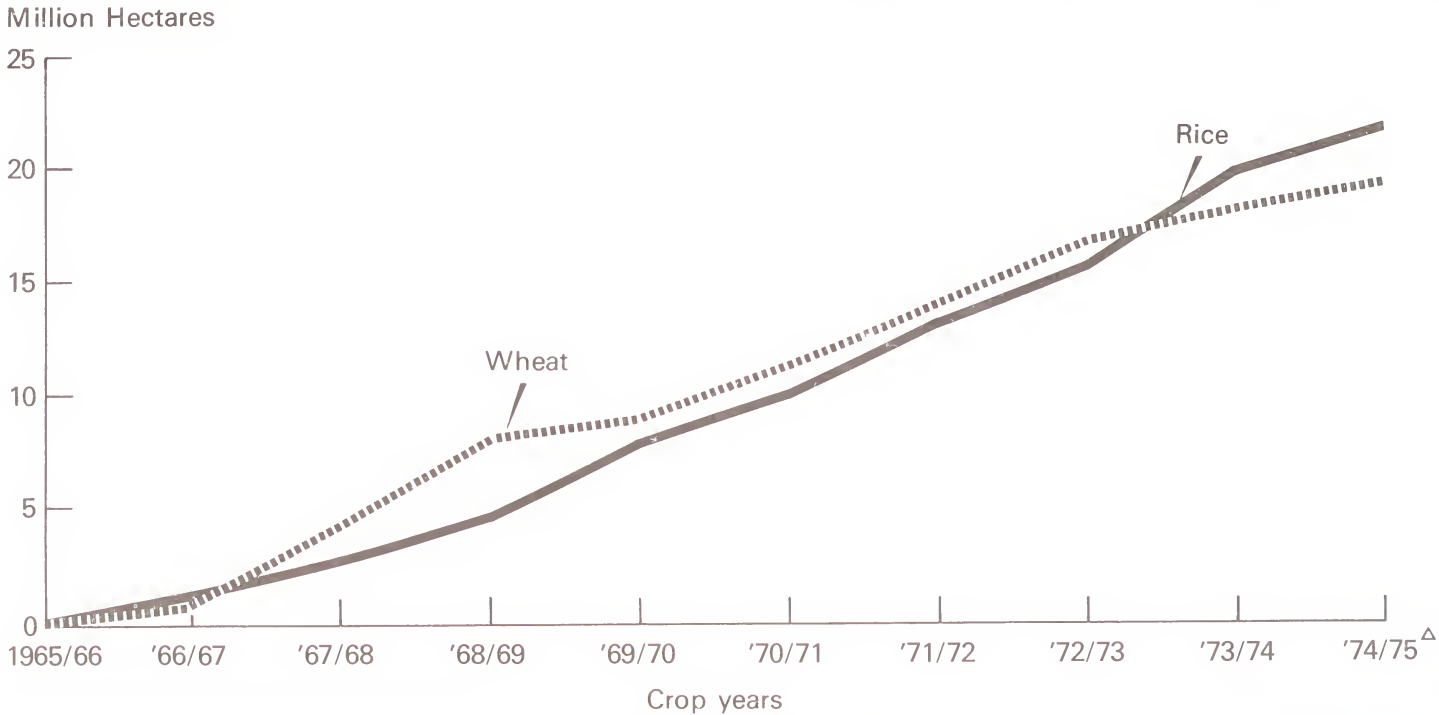
*Excluding Taiwan; including South Vietnam.

Clearly, the adoption levels for HYV wheat and rice are much higher in Asia than in the Near East. Moreover, the overall adoption level for wheat is greater than for rice.

Among individual nations in the region, India was by far the leader. In 1974/75, it accounted for about 61.1 percent of the total HYV wheat area in Asia and the Near East and about 51.2 percent of the region's total HYV rice area. Other leading nations, in terms of total area, were: wheat, Pakistan and Iraq; rice, Indonesia, the Philippines, and Bangladesh.

The proportion of total wheat and rice area in individual countries planted to HYV's varied rather widely in 1974/75. In India, the HYV's occupied nearly 62 percent of the wheat area and 30 percent of the rice area. In the case of wheat, Nepal, Pakistan, and Iraq also had high HYV proportions. The highest HYV proportions for rice were found in the Philippines and Sri Lanka.

Estimated area of high-yielding varieties of wheat and rice, Asia and Near East



Excluding developed countries and Communist nations (except South Vietnam). △*Preliminary.*

In addition to the HYV areas reported for Asia and the Near East, substantial areas were planted in Latin America and a modest area in Africa. The data are too fragmentary, however, to summarize in time series form. While improved wheat varieties of Mexican descent are planted in numerous Latin American nations, as of the mid-1970's the use of semi-dwarfs was largely concentrated in Argentina and Mexico. The total HYV area in Argentina in 1975 was quite difficult to ascertain but could have been in the millions of hectares. Nearly all the wheat area in Mexico (totaling 800,000 ha. in 1974/75) continued to be planted to HYV's. Semi-dwarf rice was raised in more Latin American countries than HYV wheat but the total area (excluding Cuba) was less—about 770,000 ha. (1.9 million acres). The total area of semi-dwarfs in Africa in 1974/75 was probably about 150,000 ha. (370,000 acres) of wheat and a few thousand hectares of rice.

The rate of HYV adoption may be expected to drop off in some nations as the area suitable for HYV cultivation is used up. Few major nations may be expected to achieve Mexico's nearly complete adoption because of a number of supply and demand factors. On the other hand, newer varieties are being developed for a broader range of environmental conditions and consumer demands. The potential exists for a significant expansion of HYV area in many countries.

I. INTRODUCTION

The greatest service which can be rendered any country is to add an useful plant to its culture; especially, a bread grain. . .

—Thomas Jefferson, 1821[1]

The use of high-yielding varieties (HYV's) of wheat and rice has expanded sharply in the less developed countries (LDC's) in recent years. These varieties, along with critical inputs such as fertilizer and water control, have formed the basis for what is popularly known as the "green revolution." This report will outline the development of these varieties and document the spread in their use.

BACKGROUND AND FOCUS OF THE REPORT

While the green revolution is a recent phenomenon in the LDC's, high-yielding varieties are not new. A vast number of wheat and rice varieties have probably, over time, been classified as high-yielding.

Improved yields can stem from any one of a number of biological characteristics or cultural practices. The distinguishing characteristic of the high-yielding wheat and rice varieties described in this report is their semi-dwarf nature. They are also generally early maturing and have several other complementary plant features.

Dwarf and semi-dwarf wheat and rice varieties have been known for many years. But they generally have been more of curiosity interest than commercial value. The dwarfing characteristic, however, became of significant importance with the advent of chemical fertilizer.

The development of chemical fertilizer promised sharp boosts in yields for plants which could respond to its application and yet not lodge (fall over). This was particularly true in intensively farmed areas where the water supply was not a limiting factor. Hence it is not surprising to find that the first efforts to develop such rice varieties probably occurred in Japan nearly a century ago.[2]

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[1] *The Jeffersonian Cyclopedia*, ed. by John P. Foley, Funk and Wagnells Co. 1900, p. 697, item 6677.

[2] In Japan, increasing application of commercial fertilizer (fishmeal, soybean cakes) in the late 1800's and chemical fertilizer in the early 1900's led to an early interest in

The use of chemical fertilizer on domestic food crops in developing countries, however, is a more recent occurrence—beginning largely in the 1950's and 1960's.[3] The high-yielding wheat and rice varieties described in this report began to make their appearance in the LDC's in the 1960's, which in turn, helped stimulate fertilizer use. The use of both HYV's and chemical fertilizer was stimulated by a food crisis in South Asia in the mid-1960's.

Thus the HYV's, while having deep historical roots, are very much a product of their time. Most of the HYV's discussed in this paper originated primarily from two international agricultural research programs—one with wheat in Mexico by Dr. Norman Borlaug and associates (subsequently grouped at the International Maize and Wheat Improvement Center—CIMMYT), and the other with rice in the Philippines at the International Rice Research Institute (IRRI). Other HYV's have been developed in national programs.

Basic information concerning the origin and interrelationships of the current HYV's will be outlined in Chapter II. Chapters III, IV, and V will provide estimates of the areas of HYV's planted or harvested in individual countries by crop years between 1965/66 and 1974/75, and some preliminary estimates for 1975/76 are also included. Scattered data on seed imports are also included where available. While the main focus is non-Communist nations, limited data on four Communist LDC's are included.

Clearly there is much other potentially useful statistical information and analysis about the HYV's which is not included in this report. No attempt is made to go beyond area data and to estimate increased yields and production.[4] Nor is any effort made to discuss the economic and social effects of the HYV's within the context of the "green revolution"—much literature is already available on this subject (a detailed list is provided in Appendix A of this bulletin). Rather, the purpose of this report is to provide a historical and statistical base for policy analysis and other research.

DEFINITIONS AND SOURCES OF DATA

Although the statistical data focus only on HYV area and seed imports, they are not without definitional complexities. The general characteristics,

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the development of varieties with shorter stems. One of the first was selected in 1877 (Takane Matsuo, *Rice Culture in Japan,* Yokendo Ltd., Tokyo, 1955, p. 13). Semi-dwarf wheat varieties, as will be noted in Chapter II, already existed in Japan at this time.

[3] Dana G. Dalrymple, *Evaluating Fertilizer Subsidies in Developing Countries,* U.S. Agency for International Development, Bureau for Program and Policy Coordination, Discussion Paper No. 30, July 1975, p. 3.

[4] Some of the major factors involved in this process, however, are outlined in a companion publication: Dana G. Dalrymple, *Measuring the Green Revolution: The Impact of Research on Wheat and Rice Production,* U.S. Department of Agriculture,

problems, and sources of data will be outlined here; more specific details will be found in the footnotes in Chapters III and IV.

Varietal Definitions

As noted earlier, the emphasis of this report is on *semi-dwarf* types of wheat and rice primarily developed by CIMMYT and IRRI and further developed in national programs.[5] These varieties, because of their semi-dwarf characteristic, are potentially high-yielding.[6] This yield capacity, however, is seldom fully realized on farms for a host of physical, biological, and management reasons which have been discussed elsewhere.[7] Thus the classification is on the basis of yield potential, rather than actual output.

This definition of HYV's does not, of course, include all improved wheat or rice varieties. *Improved* varieties of normal height, produced as a result of scientific breeding or selection, have been under development in many LDC's for decades. (In India, for example, systematic research on wheat began in 1905 and on rice in 1911.[8]) These varieties in turn may have significantly higher yields than *traditional* varieties—those which have evolved out of natural and human selection processes over centuries.[9] Many improved and traditional varieties are, of course, included in the ancestry of the current HYV's.

While every effort has been made to limit the data reported here to the semi-dwarf HYV's, this has not always been possible. National data are not always broken down by specific variety. Thus it is sometimes necessary to use whatever definition of HYV's was used by the national reporting system. This process has undoubtedly included some improved varieties. And the degree to which improved varieties are included may have changed over time.[10] Where the varietal composition is known, it is so reported.

Economic Research Service, FAER No. 106, July 1975, 40 pp. (An abridged and slightly revised version of this bulletin will appear in *Resource Allocation and Productivity in National and International Agricultural Research,* ed. by T. M. Arndt, D. G. Dalrymple, and V. W. Ruttan, University of Minnesota Press, 1976, in press.)

[5] Some of the newer IRRI varieties under development for upland and deep-water conditions will not be as short as their predecessors; hence as these varieties come into use, some exceptions will have to be made in this definition.

[6] Some other plant characteristics of the semi-dwarfs also contribute to increased yields, including a higher tillering capacity, larger grain number per spikelet in the case of wheat, and the structure of the leaf canopy in the case of rice. For further detail, see D. S. Athwal, "Semidwarf Rice and Wheat and Global Food Needs," *The Quarterly Review of Biology,* March 1971, pp. 24–26.

[7] See, for example, Dalrymple, *op. cit.* (Measuring . . .), pp. 12–17.

[8] Albert Howard and G. L. C. Howard, *The Improvement of Indian Wheat,* Agricultural Research Institute, Pusa, Bulletin No. 171, 1927, pp. 1–16: M. S. Swaminathan, "Preface," in *India's Rice Revolution, A Beginning,* All-India Coordinated Rice Improvement Project, Hyderabad, 1974, p. i. See Appendix B for a review of the development of one of the better improved varieties in the Near East.

[9] Some improved and traditional varieties may, of course, be as high-yielding as some semi-dwarfs under certain conditions. High yields are not an exclusive property of the semi-dwarfs.

[10] It has been reported, for example, that in India through 1968/69, improved local varieties were included in the HYV category. Thereafter the definition was more

A more subtle definitional problem arises from the time span covered in this report. Aside from the historical background in the next chapter, the report concentrates on the adoption of varieties that have been introduced by CIMMYT and IRRI since the mid-1960's. Semi-dwarf varieties introduced and widely adopted before that time are not specifically covered. Thus, the Ponlai rices which were developed in Taiwan in the early 1920's and widely planted thereafter are excluded. The same is true of the H series of rices in Sri Lanka. On the other hand, some of the offspring of these programs are included in national HYV figures; and one of the rice varieties developed earlier (Taichung Native 1) was distributed by IRRI. Mexico is excluded for the unusual reason that the portion of total wheat area planted to improved (not semi-dwarf) varieties surpassed 90 percent in 1957 and no subsequent annual data are available on the replacement of these varieties with semi-dwarfs.

While almost all of the HYV's reported here were developed by CIMMYT or IRRI, or are related in some way to such varieties, this is not always the case. The clearest example is some semi-dwarf varieties of wheat that were developed in Italy early this century and which are still planted in the Mediterranean region (this topic will be discussed in greater detail in the next chapter). The same may be true of some Malaysian rice varieties, though by current standards some of them may not be semi-dwarfs or very productive.

The data cover only commercial plantings; no attempt has been made to summarize the area planted for research purposes. Hence, many countries other than those listed may have HYV's under test, and may even have moved into limited commercial production.

Data Sources

Data on area and seed imports generally come from different sources. Most are unpublished. They apply, as far as possible, to July-to-June crop year plantings, although harvested area is reported in a few cases, and is so noted.[11]

The area information is largely based on reports submitted by AID country missions or USDA agricultural attachés. These data, in turn, were usually obtained from official reports or estimates by the countries themselves. The national systems for collecting this information may not, in many cases, be very advanced. While the data have been checked as far as possible, there is really no good way of knowing how accurate they are. In some cases the HYV area may be overestimated;[12] in others it may be

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strict. (V. S. Vyas, *India's High-Yielding Varieties Programme in Wheat, 1966–67 to 1971–72,* CIMMYT, 1975, pp. 5, 7.)

[11] This process is not very precise and is subject to error, particularly where crop seasons, such as the aus (spring-summer) rice crop in Bangladesh, cut across the above time period. The assignment of some crops to specific crop years may, therefore, be open to question. The harvesting period follows the planting data by at least 3 months, creating further difficulties in making a consistent classification by crop years.

[12] I know of only one documented example which suggests this. In the south-eastern half of North Arcot District of Tamil Nadu in India in 1972/73, official data

understated;[13] and for others (such as Cambodia) it may simply not be available. The area data, therefore, should be regarded as only approximate.

The seed figures are believed to be relatively accurate, but quite incomplete except for unusually large shipments from Mexico, the Philippines, and India. Virtually all of the statistics on Philippine rice exports were provided by IRRI.

SOME BASIC BIOLOGICAL CHARACTERISTICS

While the basic biological characteristic of the high-yielding varieties discussed in this report is their semi-dwarf growth habit, some other biological features are also important. These features are in part related to their botanical classifications: there are several different major species and types of wheat and rice. Wheat and rice have somewhat different growing seasons, and their water needs also vary.

Classification of Wheat and Rice

In terms of botanical classification, wheat belong to the genus *Triticum* and rice to the genus *Oryza*. Wheat is composed of three species of commercial importance, while commercial rice is principally composed of one species.

Wheat.[14] The three major species of wheat are: common or bread wheat (*Triticum aestivum* L.); club wheats (*Triticum compactum* Host); and durum wheat (*Triticum durum* Desf.). Bread wheats were first extensively grown in northern Europe; club wheats in southern Europe; and the durum wheats in the Mediterranean countries, in southern and eastern Russia, and in Asia Minor. Each species has distinct characteristics which make it

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for 6 tulaks indicated that 39 to 48 percent of the rice area was planted to HYV's. An unofficial survey of 545 farmers in 11 villages in the region, however, revealed that only 13.4 percent of the area was so planted. Thus, the official adoption data suggested a figure about three times as high as indicated in the survey. Whether the same results would have been found elsewhere in Tamil Nadu or other regions is, of course, not known. (B. Nanjamma Chinnappa, "Adoption of the New Technology for Paddy Cultivation in the Survey Area," Project on Agrarian Change in Rice Growing Areas of Tamil Nadu and Sri Lanka, University of Cambridge, Centre of South Asian Studies, pp. 3, 6, 7; to be published in *Green Revolution?*, ed. by B. H. Farmer, Macmillan, London. Letters from: Mrs. Chinnappa; September 24, 1975, October 22, 1975; Robert Chambers, Geneva, Switzerland, September 11, 1975.)

[13] In Turkey, for instance, the estimates cited in this report indicated an area of 623,000 to 650,000 ha. of Mexican varieties in 1971/72. Yet a comprehensive independent survey during the same period suggests a total of about 1 million ha. (see footnotes 3 and 6 in the Turkey table). In some countries, such as Morocco, the official data refer only to the HYV area under government programs; private plantings are not included.

[14] Dr. L. W. Briggle of the Agricultural Research Service, U.S. Department of Agriculture, Beltsville, helped prepare this section.

suitable for special uses: the common wheats are used for bread; the club wheats, which are soft, are used for pastry; and the durum wheats, which are hard, are used for products such as macaroni and spaghetti. Nearly all of the varieties reported in this publication are bread wheats. HYV durum varieties, however, are gaining in importance in the Mediterranean countries. Club wheats are presently of minor international importance.

Rice.[15] Asian or common rice (*Oryza sativa* L.) is the major species of cultivated rices. There are two major eco-geographic races within this species: indica and japonica. (Japonica is sometimes known as sinica or keng.)

Indica is the major group grown throughout South and Southeast Asia and in most areas of the People's Republic of China. The majority of indica varieties raised in the monsoon tropics have evolved from combined natural and human selection processes. They are well adapted to conditions of low soil fertility, uncertain weather, and poor water control. Most indicas have resistance to endemic diseases and insects and compete well with weeds. They also have the dry cooking characteristics preferred by consumers in tropical and sub-tropical areas. But the features that enable the tropical types of indicas to survive—tall and high tillering plants, late maturity, long drooping leaves, etc.—also provide the basis for their weakness under modern agricultural practices. Improved fertilization, for instance, will lead mainly to vegetative growth and lodging rather than significantly increased yield.

Japonica varieties are widely distributed in different areas of the temperate zone: lower Yangtze valley of China, Korea, Japan, Europe, parts of Australia, and California in the United States. The japonica varieties evolved in China more recently than the indicas and are the result of an intensive human selection process. In comparison with the indicas, they have darker and more upright leaves, a shorter and stiffer stalk, earlier maturity, and more thrifty vegetative growth. Japonicas respond well to improved cultural practices—especially fertilizer—and are more resistant to lodging. As a result, yields are considerably higher than for the indicas. Japonicas are not, however, well adapted for the traditional cultural practices in tropical Asia. Among other things, (1) the varieties require precise water, weed, and insect control; (2) most are susceptible to the virus diseases of the tropics; (3) some react to the high temperature during early growth stage by flowering too early; (4) they lack the grain dormancy needed in the monsoon season; and (5) the grains have a sticky cooking quality not desired by consumers.

Breeding efforts, to be outlined in the next chapter, have centered about improving each of these types as well as developing japonica and indica crosses.

Growing Seasons

Wheat is basically a temperate and semi-tropical crop, while various types of rices may be grown in regions ranging from the warmer

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[15] Dr. T. T. Chang of IRRI was a great help in preparing this section. For further details see Takane Matsuo, *Rice and Rice Cultivation in Japan,* Institute of Asian

temperature zones to the tropics. In each case, the normal range can be extended somewhat by breeding efforts and cultural practices.

Both the Mexican-type wheats and IRRI-type rices have some flexibility with respect to planting date in the developing nations. That is, they may be grown in the dry winter season and wet summer season. There are, however, some differences between the two crops.

Wheat. Wheat is of two types, winter and spring. Botanically, the Mexican varieties are spring wheats (i.e., planted in the spring and harvested in late summer). Where winters are mild, spring wheats may, like winter wheats, be planted in the fall and harvested in the spring. This practice is enhanced by the photoperiod-insensitive nature of the Mexican wheats. The winter culture of spring wheats is generally utilized in the less developed nations in warm regions.[16] In some regions where there is a heavy summer monsoon, culture of Mexican varieties may be largely limited to the winter season. Virtually all of the data reported here are for spring wheats, though some supplementary estimates for winter wheat are included for a few Near East countries.

Rice. The wet summer season is the traditional period for rice culture. Where irrigation or sufficient rainfall is available in tropical areas, rice may also be grown during the winter and spring months. In fact, in many areas, the IRRI-type rices are more responsive to nitrogen fertilizers and produce higher yields during the dry spring months when high solar radiation prevails.[17] Significant quantities of the HYV's are planted during this period in some countries.[18] In addition, the photoperiod insensitivity of the HYV's usually shortens their growing period.[19] This, in turn, may facilitate multiple cropping.[20]

Economic Affairs, Tokyo, 1961, pp. 9-25; T. T. Chang, "Rice," in *Evolution of Crop Plants* (N. W. Simmonds, ed.), Longman, London, 1976, pp. 98-104.

[16] In Turkey, it is possible to plant Mexican varieties during the winter in the southern coastal areas, but it is necessary to use winter wheat varieties in the cold, dry Anatolian Plateau.

[17] T. T. Chang, "The Genetic Basis of Wide Adaptability and Yielding Ability of Rice Varieties in the Tropics," *International Rice Commission Newsletter*, 1967 (Vol. 16, No. 4), pp. 4-12. Most LDC's have low potential photosynthesis values in the wet summer months because of cloud cover; this is one reason why summer rice yields are relatively low in many LDC's (Jen-Ju Chang, "Potential Photosynthesis and Crop Productivity," *Annals of the Association of American Geographers*, 1970, p. 98).

[18] During the 1974/75 season, the following proportions of HYV area were planted in the winter: Bangladesh, 46 percent; Indonesia, 35 percent; and Thailand, 85 percent (based on footnotes to country tables in Chapter IV).

[19] The extent to which this is true depends on the specific variety, location, and crop season. In the more heavily planted areas of Asia, the improved varieties mature in 105 to 135 days during the wet season, some 5 to 60 days sooner than traditional varieties (Palman 579 matures in 115 days in the Punjab State of India). There are a few exceptions associated with low temperatures and long days; during the aus (summer) season in Bangladesh, for example, some indigenous varieties may mature faster than IR-8 or IR-20. (Letter from T. T. Chang, IRRI, October 25, 1973; for details see Chang and B. S. Vergara, "Ecological and Genetic Aspects of Photoperiod-sensitivity and Thermo-sensitivity in Relation to the Regional Adaptability of Rice Varieties," *International Rice Commission Newsletter*, June 1971).

[20] Weather and water supply permitting. The same may be true of wheat. For more information on multiple cropping, see Dana G. Dalrymple, *Survey of Multiple*

Relation to Irrigation[21]

High-yielding types of both wheat and rice tend to be raised under irrigated conditions. Since the high-yield potential of the varieties is achieved by applying inputs such as fertilizer, an added cost is involved. When water control—both supply and drainage—is inadequate or unreliable, the added risk discourages the use of these and other inputs, and thus reduces or eliminates the advantage of the varieties.

Both the quality of irrigation systems and the need for irrigation vary widely in the developing nations. Irrigation systems range from virtually complete year-round supply to occasional supplementation of rainfall. Most commonly, the systems supplement rainfall during the wet season and service only a limited area during the dry season. High-yielding varieties do not require more water than local varieties in a physiological sense; in fact, because of higher yields and shorter growing periods, they may actually use less per unit of product. But, as noted above, the attainment of the full potential of the HYV's without undue risk requires an assured water supply. This increases the demand for water.[22]

Wheat and rice water requirements vary sharply. Rice, which is largely grown under flooded or paddy conditions, requires much more water per unit of land than wheat—over three times as much under some Indian conditions.[23] Thus, rice is most often raised in monsoon areas and wheat in the drier climates. Similarly, rice is more often grown during the wet season and wheat during the dry season. In some instances, where growing seasons permit, they are able to follow each other in multiple cropping rotations.[24]

Wheat. About 2/3 of the high-yielding wheat varieties are raised under irrigated conditions, principally in India and Pakistan.[25] Some important regions, however, such as north Africa and the barani (rainfed) area of Pakistan, receive little, if any, irrigation.[26] Even without irrigation, yields of the HYV's are often superior to local varieties. Consequently, increased

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Cropping in Less Developed Nations, Economic Research Service, U.S. Department of Agriculture (in cooperation with AID), FAER No. 91, October 1971, 108 pp.

[21] Drs. Randolph Barker and T. T. Chang of IRRI were of help in preparing this section.

[22] In economic parlance, the HYV's may raise the marginal value product (mvp) of water. This increase, however, may be of little practical value where added irrigation water is not available, as is often the case in canal irrigated regions. On the other hand, the higher mvp may stimulate tubewell installation or the purchase of tubewell water.

[23] Several references as summarized by Dalrymple, *op cit.*, October 1971, p. 31.

[24] *Ibid.*, pp. 65, 71, 75, 78, 95; *CIMMYT Annual Report, 1972,* p. 46 (ref. to India).

[25] Letter from Don Winkelmann, CIMMYT economist (citing estimate by R. Glenn Anderson of CIMMYT), February 4, 1974; letter from Anderson, February 4, 1974.

[26] See, for example: Malcolm J. Purvis, "The New Varieties Under Dryland Conditions; Mexican Wheats in Tunisia," *American Journal of Agricultural Economics,* February 1973, pp. 54–57; R. I. Rochin, "A Micro-Economic Analysis of Smallholder Response to High-Yielding Varieties of Wheat in West Pakistan," Michigan State University, Dept. of Agricultural Economics, Ph.D. dissertation, 1971.

attention is being given to developing increased drought-resistant wheat varieties.[27]

Rice. The high-yielding rice varieties are largely grown under irrigated lowland conditions and the remainder in the better rainfed areas. While precise figures are not available, the irrigated proportion is probably at least 75 percent for South and East Asia as a whole. The major exception is the Philippines where only 55 percent of the HYV's were grown on irrigated land in 1973/74 (table 30). As of the early 1970's, about 33 percent of the total rice area in South and East Asia fell into the irrigated category, 57 percent was rainfed (47 percent rainfed lowland and 10 percent rainfed upland), and 10 percent was deep water. Thus the HYV's have largely been confined to a relatively small proportion of the rice area in Asia.[28] Research workers at IRRI and elsewhere are attempting to develop varieties which will better withstand the drought conditions associated with upland and rainfed lowland rice production,[29] or the deep water and poor drainage conditions in the low-lying areas of major river deltas.[30]

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[27] One approach being used at CIMMYT is to cross spring wheat with winter wheat, which has greater drought tolerance.

[28] Based on: a discussion with Randolph Barker, IRRI economist, February 4, 1976; R. Barker, H. E. Kauffman and R. W. Herdt, "Production Constraints and Priorities for Research," IRRI, Agr. Econ. Paper No. 75-8, April 1975, fig. 75-8. Also see Randolph Barker, "The Evolutionary Nature of New Rice Technology," *Food and Research Institute Studies,* Vol. X, No. 2, 1971, pp. 119, 121.

[29] For details, see the following IRRI publications: *Research Highlights for 1974* (1975); pp. 38–42; *Annual Report for 1974* (1975), pp. 105–123; *Major Research in Upland Rice*, 1975, 255 pp. Recently, IRRI has been investigating direct seeding under rainfed lowland conditions (see "Two Crops of Rainfed Rice," *The IRRI Reporter*, 5/75, pp. 1–3).

[30] For details, see: B. R. Jackson, *et al.*, "Breeding Rice for Deep-Water Areas," *Rice Breeding,* 1972, IRRI, pp. 517–518; *Research Highlights for 1974, op. cit.*, pp. 46–50; and the *Annual Report for 1974, op. cit.*, pp. 135–145.

II. ORIGIN AND DEVELOPMENT

The origin and development of the varieties reported in this bulletin are considerably more involved than their simple classification as semi-dwarf Mexican wheats and IRRI rice varieties might suggest. Moreover, through history many varieties have emerged and been used which share at least some of their major characteristics.[1]

HIGH-YIELDING WHEAT

The wheat varieties discussed here are descendents of Japanese, American, and Italian varieties and breeding efforts. These varieties first emerged, in recorded form, in the middle 1800's and the early 1900's.

They were not, however, the first to show some of the major characteristics of the present varieties. The earliest known example for wheat occurred on June 30, 1794, when the *American Mercury* of Hartford, Connecticut, published "An Account of a New Species of Wheat." The new variety was a hard winter wheat which, compared to the prevailing species, matured 15 to 20 days earlier, provided a heavier yield, and produced a third less straw on a short stem. It was also disease resistant (particularly with respect to rust), and because of its earlier maturity escaped the worst damage of the Hessian fly. The variety was known as Forward Wheat and came from Caroline County, Virginia, where it had been selected 7 years earlier. Seed was offered for sale in Connecticut in September 1795. By 1798–1800 it was generally grown in eastern Virginia and Maryland, and was presumably adopted in the commercial wheat-growing areas of western New England.[2] Other such "modern" varieties may well have emerged unrecorded over time.

Japanese-American Roots

Japan has had a long history in the development of dwarf wheat. In 1873, Horace Capron, former U.S. Commissioner of Agriculture who

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[1] The reader desiring more technical detail than is provided in this chapter may wish to consult D. S. Athwal, "Semidwarf Rice and Wheat and Global Food Needs," *The Quarterly Review of Biology,* March 1971, pp. 1–34.

[2] Based on Chester M. Destler: " 'Forward Wheat' for New England: The Correspondence of John Taylor of Caroline with Jeremiah Wadsworth, in 1795," *Agricultural History,* July 1968, pp. 201–205; "The Gentleman Farmer and the New

headed an agricultural advisory group to Japan, wrote that "the Japanese farmers have brought the art of dwarfing to perfection." He noted that "the wheat stalk seldom grows higher than 2 feet, and often not more than 20 inches." The head was short but heavy. The Japanese claimed that the straw had been so shortened "that no matter how much manure is used it will not grow longer, but rather the length of the wheat-head is increased." Capron noted that "on the richest soils and with the heaviest yields, the wheat stalks never fall down and lodge."[3]

Probably unknown to Capron, some Japanese wheat varieties had already been introduced in France. The first introduction occurred in mid-1867 when the "Société d'Acclimatation" of Paris received seed of a very productive early wheat ("blé précoce") listed as Haya Moughi, from a Dr. Mourier in Yokohama.[4] The seeds were planted by a member of the Society and a preliminary report was presented that fall. The stem or straw was short and the plant flowered early.[5] In the following years, other seeds were imported and numerous reports of trials of the "ble précoce" appeared in the *Bulletin* of the Society.[6] In 1880, it was listed in the well-known book, *Les Meilleurs Blés*. According to the description, the straw was very short, erect, and stiff; the plant was reported to flower 2 to 3 weeks ahead of all the other spring wheats. The entry, however, noted that the variety was more of curiosity interest than of true agricultural merit.[7] "Blé Précoce du Japon" was sold commercially from 1882 to 1904 as a spring wheat. It was used for experimental breeding work from 1930 to 1955, but does not appear to have been involved in the parentage of any significant commercial varieties.[8]

Two Japanese semi-dwarf varieties, however, did turn out to be of immense international consequence in subsequent breeding programs. They were Akakomugi and Shiro Daruma.

Agriculture: Jeremiah Wadsworth," *Agricultural History,* January 1972, pp. 145–147. Also noted in E. L. Jones, "Creative Disruptions in American Agriculture, 1620–1820," *Agricultural History,* October 1974, pp. 523–524.

[3] Horace Capron, "Agriculture in Japan," *Report of the Commissioner of Agriculture for the Year 1873,* Washington, 1974, p. 369.

[4] *Bulletin de la Société d'Acclimatation,* Paris, 1867, pp. 453 ("Séance du 5 Juillet 1867"), p. 784. Subsequently, a Mr. Ramel claimed that he first drew attention to early Japanese wheat in 1862 and attempted to introduce it, but apparently was unable to obtain seed samples (*Ibid.*, 1869, p. 168).

[5] *Ibid.* (1867), pp. 702–703.

[6] *Ibid*: 1868, pp. 514, 522–523, 665–666, 674; 1869, pp. 486–487; 1870, p. 229; 1871, p. 503; 1872, p. 788. Two entries suggested subsequent doubt that wheat was actually raised in Japan (1869, pp. 202, 703).

[7] [Henry Vilmorin] "Blé Précoce du Japon," *Les Meilleurs Blés,* Vilmorin-Andrieux & Co., Paris, 1880, pp. 120, 121. Vilmorin-Andrieux was one of the leading seed firms of France. The varieties were also noted in another Vilmorin-Andrieux publication: *Catalogue Méthodique et Synonymique des Froments,* 1889, pp. 18, 36, 39.

[8] Letters from: Kenneth E. Ogren, Agricultural Attaché, American Embassy, Paris, December 8, 1975; P. Martin, Union des Cooperatives Agricoles de Céréals (UCOPAC), Verneuil l'Etang, March 12, 1976. UCOPAC acquired the cereals branch of the Vilmorin-Andrieux firm; it still has a small stock of the seed, and at my request has provided a sample to the Agricultural Research Service, USDA, Beltsville. Martin notes that while the variety was short by the standards of the time, it would no longer be considered so.

Akakomugi means red wheat in Japanese.[9] According to a book written in 1929, "Akakomugi was often used as a cross-parent because of dwarfness and early maturity." It was mainly raised in southern Japan but is no longer grown commercially. Akakmougi played an important role in the breeding of Italian semi-dwarf varieties early in the 20th century (to be discussed in a following section).

Shiro means white in Japanese (a red strain is known as Aka Daruma).[10] In 1917, Shiro Daruma was crossed with Glassy Fultz, a selection of the American soft red winter variety Fultz, at the Central Agricultural Experiment Station, Nishigahara, Tokyo, to produce Fultz-Daruma.[11] This variety in turn was crossed with the American hard red winter variety Turkey Red[12] at the Ehime Perfectural Agricultural Experiment Station in 1925[13] in an effort to produce rust-resistant, short-stemmed, early-maturing varieties. The seeds of the first generation of the cross were transferred to the Konosu Experimental Farm of the National Agricultural Experiment Station and planted in 1926. Seed was subsequently sent to the Iwate Prefectural Agricultural Experiment Station in northeastern Japan.

A semi-dwarf selection developed from the seventh generation in 1932, Tohoku No. 34, was particularly promising. Following further testing, it was named *Norin 10* and registered and released in October 1935. The stem of Norin 10 was particularly short, having a length of 52 to 54 cm. Norin 10 was in turn used in breeding programs in Japan, the United States, and Mexico (the latter two cases are discussed in a following section). Shiro Daruma was also used at the Iwate Station to breed Norin 1 in 1929 and Norin 6 in 1932.

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[9] This section is based on a letter from T. Gotoh, Wheat Breeder, Tohoku National Agricultural Experiment Station, Morioka, Japan, October 31, 1975. The book cited is Soshichiro Takeda, *Mugisaku Shinsetsu* (New Technique of Wheat Cultivation), 1929.

[10] This section is based on: Takeo Matsumoto, "Norin 10, A Dwarf Winter Wheat Variety," *Japan Agricultural Research Quarterly,* 1968, (Vol. 3, No. 4), pp. 22-26; Gonjiro Inazuka, "Norin 10, a Japanese Semi-Dwarf Wheat Variety," Wheat Information Service, Biological Laboratory, Kyoto University, No. 32, March 1971, pp. 25-30; L. P. Reitz and S. C. Salmon, "Origin, History, and Use of Norin 10 Wheat," *Crop Science,* November-December 1968, p. 686; letters from T. Gotoh, *op. cit.*, October 3, 1975, November 11, 1975; letter from Hiroyuki Nishimura, Department of Agricultural Economics, Kyoto University, October 1, 1975; and letter from Noboru Yamada, Tropical Agriculture Research Center, Ministry of Agriculture and Forestry, Tokyo, October 31, 1975. (Gotoh provided a copy of the Inazuka article; Yamada a reprint of the Matsumoto paper.)

[11] Fultz was first selected in Kansas in 1862. It was imported by the Japanese Government in 1887 (Gotoh, *op. cit.*, October 3, 1975). For details on Fultz, see J. A. Clark et al., *Classification of American Wheat Varieties,* U.S. Department of Agriculture, Bulletin No. 1074, November 1922, pp. 83-85.

[12] Turkey Red, better known as Turkey, was introduced in Kansas in 1874 by a group of Russian Mennonites; it later became the leading U.S. variety. For details, see: Clark, *op. cit.*, pp. 144-147; and K. S. Quisenberry and L. P. Reitz, "Turkey Wheat: The Cornerstone of an Empire," *Agricultural History,* January 1974, pp. 98-114.

[13] The site of this original cross is incorrectly given in several accounts (Matusmoto places it at Konosu and Reitz and Salmon place it at Nishigahara). Attribution to Ehime is confirmed by: Inazuka, *op. cit.*, pp. 25-26; Gotoh, *op. cit.*, November 11, 1975; and Yamada, *op. cit.*

Italian Varieties[14]

In 1911, seed from some of the short-straw, early maturing Japanese wheat varieties was acquired by Dr. Ingegnoli, an Italian flower seed producer, during a trip to Japan. He, in turn, provided the wheat seed to Nazareno Strampelli at the Royal Wheat Growing Experimental Station at Rieti. Strampelli started using the Japanese varieties in his breeding programs in 1912.[15]

Strampelli was interested in developing wheat plants which would be both early ripening and resistant to lodging. Early ripening was desired to increase resistance to blast or "stretta" (wilting under hot wind stress) and rusts, and to facilitate cropping. Resistance to lodging, obtained through shorter and thicker stems, was desired so fertilizer applications could be increased. These goals (aside from resistance to "stretta") were very similar to those of later breeding programs and seem to have been largely accomplished.[16]

Of the several Japanese varieties used by Strampelli, Akakomugi appeared to be the most important. In 1913, it was crossed with Wilhelmina Tarwe X Rieti (a cross involving Dutch and Italian varieties originally made in 1906), producing two lines: (1) *m. 67* and (2) *21 ar.* The former produced Villa Glori (1918) among other well known varieties. The latter produced, among others, Ardito (1916) and Mentana (1918).[17]

Ardito was the first variety to attain wide use. It had short straw (70–80 cm.) and early-maturing characteristics. By 1926, it accounted for nearly all of the 500,000 ha. (1,240,000 acres) planted to early maturing varieties in Italy.[18] Ardito was also grown in other areas of the world and became one of the progenitors of improved Argentine varieties and of the Russian winter variety Bezostaya.[19]

Mentana was the second major variety. It differed from Ardito in that it had earlier maturity and a longer stem (90–100 cm.). Mentana attained international popularity due to its resistance to yellow rusts. Its genetic

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[14] This section developed out of brief mention of the Italian wheats in Reitz and Salmon, *op. cit.*, p. 688. Valuable assistance was provided by Dr. Reitz as well as by: A. Brandolini, FAO; and Alessandro Bozzini, Director, Laboratorio per le Applicazioni in Agricultura, Centro di Studi Nucleari della Casaccia, Rome.

[15] Letters from Bozzini, *op. cit.*, December 5, 1973, February 5, 1974. In 1922, Strampelli moved to "The National Institute of Genetics as Related to the Cultivation of Cereals" in Rome. Biographical material on Strampelli is provided in *Nazareno Strampelli,* Societa Ploesana Produttori Sementi, Ramo Editoriale Degli Agricoltori, Rome, 1966, 44 pp.

[16] Nazareno Strampelli, *Early Ripening Wheats and the Advance of Italian Wheat Production,* Tipografia Failli, Rome, 1933, pp. 5–7.

[17] *Origini, Sviluppi, Lavori e Risultati,* Instituto Nazionale di Genetica per la Cerealicoltura in Roma, Rome, 1932, pp. 91, 92, 99–101, appendix. (Actual release dates for farm use were 4 or 5 years later than noted here.)

[18] Strampelli, *op cit.*, p. 11, maps and tables.

[19] Letters from: R. Glenn Anderson, International Maize and Wheat Improvement Center, October 19, 1973; Brandolini, *op. cit.*, March 8, 1974; Nicolae Saulescu and J. Vallega, in *Nazareno Strampelli, op. cit.*, pp. 30, 43. (The full pedigree of Bezostaya 1 is provided in *Cereal Improvement and Production,* Information Bulletin, Near East Project, FAO, 1971, No. 2-3.)

traits were bred into Frontana (Brazil) and Kentana (Mexico).[20] Mentana was also one of three varieties which played a key role in the Mexican wheat breeding program in the 1940's.[21]

As a result of a wheat campaign in Italy, an estimated 1,261,000 ha. (3,116,000 acres) of early wheats were grown by 1932. This represented 25.4 percent of the total wheat area. The early wheats, mainly Mentana and Villa Glori, were particularly concentrated in the northern provinces.[22]

The typical varieties raised during the 1930's (such as Mentana) were taller than those used in the 1920's (such as Ardito). Subsequent breeding efforts placed increased emphasis on breeding a shorter stem, and the height of most varieties ranges from 65 to 85 cm.[23] Some varieties have a stalk length of less than 40 cm.[24]

Italian varieties are now being grown in several less developed countries in the Mediterranean region, particularly Morocco, Algeria, and Turkey. One of the better-known varieties is Strampelli; while it is susceptible to stem rust, it has good resistance to septoria.[25] Italian and Japanese varieties were used in early breeding work in Tunisia.[26] Italian varieties are also widely used in southeastern Europe.[27]

While the Italian varieties are generally early maturing and have relatively short straw, their stalk differs from the Mexican wheats. In some varieties, it is stiff and brittle with a completely upright head, in contrast to the more flexible Mexican-type straw.[28]

Italian varieties are currently being used in a number of nations, and appear to have played an important role in the development of other varieties, including some of the early Mexican varieties.

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[20] Bozzini, *op. cit.*; Brandolini, *op. cit.*

[21] Norman E. Borlaug, "Wheat Breeding and Its Impact on World Food Supply," *Proceedings of the Third International Wheat Genetics Symposium,* Canberra, 1968, p. 5. The other two varieties were Florence Aurore (Marroqui)—see Appendix B—and Gabo.

[22] Strampelli, *op. cit.*

[23] Bozzini, *op. cit.*

[24] Mario Bonvicini, "Indirizzi della Genetica Agraria per la Resistenza All'allettamento in Triticum Vulgare," *Caryologia* (Suppl. Atti del IX Congresso Internazional di Genetica), 1954, pp. 738-743.

[25] Anderson, *op. cit.*; letter from Willis McCuistion, Project Cereales—CIMMYT, Algiers, Algeria, December 11, 1973.

[26] F. Boeuf, "Le Blé en Tunisie," *Annales du Service Botanique et Agronomique,* Tunis, Tome VIII, 1932, pp. 96-110. In addition, several hybrids obtained from Emile Schribaux of Versailles early in the century reportedly had stiff stems and were early ripening (*Ibid.*, pp. 60, 61). The most important was Florence x Aurore (see Appendix B). Neither Florence Aurore or any of the other varieties appeared to be of Japanese or Italian origin (based on Appendix B and an examination of the names of the other varieties enclosed with a cover letter from Schribeaux to Boeuf, December 2, 1922, a copy of which was kindly provided by P. Auriau, Station Genetique et d'Amelioration des Plantes, CNRA, Versailles, September 10, 1975).

[27] Letter from Bill C. Wright, Wheat Research and Training Center, Ankara, November 8, 1973. Wright specifically mentions Albania, Bulgaria, Hungary, and Yugoslavia. Also see Saulescu, *op. cit.*

[28] Anderson, *op. cit.*

Mexican Varieties

In 1946, Dr. S. C. Salmon, a U.S. Department of Agriculture scientist acting as agricultural advisor to the occupation army in Japan, noticed Norin 10 growing at the Morioka Branch Research Station in northern Honshu. The stems were short, about 60 cm., but produced many full-sized heads. Dr. Salmon brought 16 varieties of this plant type to the United States. They were grown in a detention nursery for a year and then made available to breeders in the seven locations.

Although Norin 10 was not satisfactory for direct use in the United States, it was useful for breeding.[29] Dr. Orville A. Vogel, a U.S. Department of Agriculture scientist stationed at Washington State University, was the first to recognize its worth and to use it in a breeding program in 1949. Crossing Norin 10 with U.S. varieties involved some problems, but a number of semi-dwarf lines were eventually developed. A Norin 10 X Brevor cross was to become particularly important.[30]

In the interim, word about the short-strawed germ plasm had reached Dr. Norman Borlaug in Mexico.[31] His breeding efforts had run into a yield plateau because of lodging under high levels of nitrogen fertilization. In his words:

> We had recognized the barriers in our search for a useable form of dwarfness to overcome this problem until the discovery of the so-called Norin dwarfs. In 1953 we received a few seeds of several F_2 selections from the cross Norin 10 X Brevor from Dr. Orville Vogel. Our first attempts to incorporate the Norin 10 X Brevor dwarfness into Mexican wheats in 1954 were unsuccessful . . . A second attempt in 1955 was

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[29] Norin 10, when grown in the United States and Mexico, proved to be daylight sensitive, very susceptible to rusts, and had shriveled or shrunken grain (letter from Charles F. Krull, Dekalb Italiana, Chiarno, Italy, January 29, 1976).

[30] Reitz and Salmon, *op. cit.*, pp. 686-687; L. P. Reitz, "Short Wheats Stand Tall," *1968 Yearbook of Agriculture,* U.S. Department of Agriculture, pp. 236-237; L. P. Reitz, "New Wheats and Social Progress," *Science,* September 4, 1970, pp. 952-955. Brevor was developed from a cross between Brevon (Turkey-Florence X Fortyfold-Federation) and an unnamed cross between Brevon's parents and Oro. It was developed cooperatively by the U.S. Department of Agriculture and the Washington Agricultural Experiment Station. The original cross was made in 1938 and the variety was released in the fall of 1949. (L. W. Briggle and L. P. Reitz, *Classification of Triticum Species and of Wheat Varieties Grown in the United States*, U.S. Department of Agriculture, Technical Bulletin No. 1278, May 1963, p. 64; discussion with Dr. Briggle, January 6, 1976.)

[31] The Rockefeller grain program in Mexico began in 1943. It was conducted in cooperation with the Office of Special Studies of the Ministry of Agriculture. In 1959, Borlaug became director of Rockefeller's International Wheat Improvement Project. The wheat program was merged with a comparable corn program in October 1963 to form the International Center for Corn and Wheat Improvement. Work sponsored by the Mexican Government was shifted from the Office of Special Studies to the National Institute of Agricultural Research in January 1961. (E. C. Stakman, R. Bradfield, and P. C. Mangelsdorf, *Campaigns Against Hunger*, Belknap/Harvard University Press, 1967, pp. 5, 12, 273.) For a more personal history of Borlaug's work, see Lennard Bickel, *Facing Starvation; Norman Borlaug and the Fight Against Hunger*, Readers Digest Press, 1974, 376 pp.

successful and immediately it became evident that a new type of wheat was forthcoming with higher yield potential.[32]

The introduction of the Norin 10 genes led to the development of a number of Mexican dwarf and semi-dwarf bread wheat varieties: Pitic 62, Penjamo 62, Sonora 63, Sonora 64, Mayo 64, Lerma Rojo 64, Inia 66, Tobari 66, Ciano 67, Norteno 67, and Siete Cerros. In addition, a semi-dwarf durum, Oviachic 65, was developed. (The number in each after the varietal name indicates the approximate year of introduction; Pitic 62 and Penjamo 62, for example, were first released to farmers in 1961.[33]) The genetic origins of these early hybrid varieties are depicted in figure 1.[34]

International diffusion of these varieties began very quickly at the experimental level. India and Pakistan were the first to be substantially involved.

The first Mexican wheats arrived in India in 1962 via the international rust nursery system. They caught the eye of Dr. M. S. Swaminathan of the Indian Agricultural Research Institute (IARI). In March and April of 1963, Borlaug, at the request of IARI, toured wheat areas in India. Upon his return to Mexico, he dispatched 100 kg. (220 pounds) of each of four varieties (Sonora 63, Sonora 64, Lerma Rojo, and Mayo), and small samples of 613 other selections. The material was grown and studied at seven locations during the 1963/64 season (as part of the All-India Coordinated Wheat Trials). In 1965, Lerma Rojo and Sonora 64 were released for general cultivation. Subsequently, 250 metric tons of Mexican seed were purchased for planting during the 1965 season and 18,000 tons for the 1966/67 season.[35]

In the spring of 1962, Borlaug gave some of the improved seeds to two

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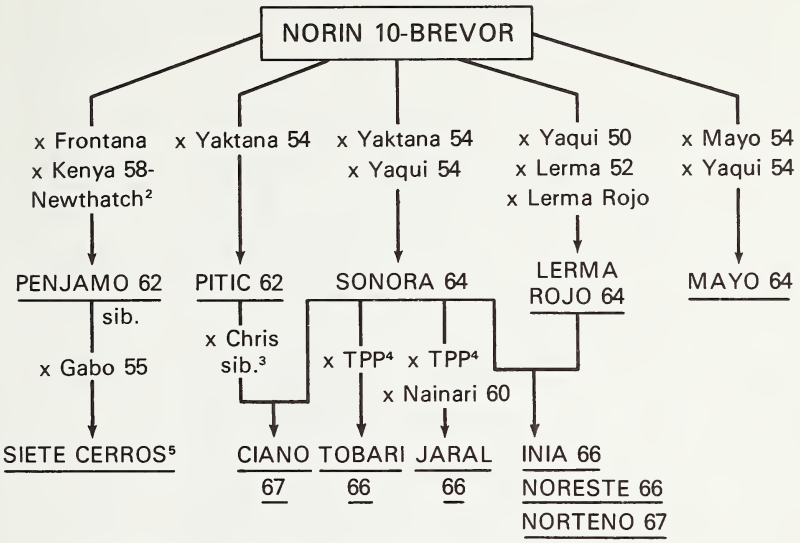
[32] Borlaug, *op. cit.*, p. 6. Although the Italian variety Mentana was, as noted in the previous section, used in early breeding efforts, it had a relatively long stem and was not in the semi-dwarf category; it did, however, introduce daylength insensitivity. For further discussion of the use of Mentana, see fn. 34 below and Stakman, *et al., op. cit.*, pp. 84–88 (curiously, this book says very little about the Norin 10 types). For background on Borlaug's introduction to the Norin 10 X Brevor crosses, see Bickel *op. cit.*, pp. 198, 208, 209.

[33] Borlaug, *op. cit.*, pp. 6–7. Pitic was the first semi-dwarf variety to be released. Borlaug notes that these varieties did not have an effect on production until 1963.

[34] Mentana was one of the parents or grandparents of several of the varieties crossed with Norin 10-Brevor: Fontana (from Brazil), Lerma 52, Lerma Rojo^2, and Yaktana 54. It was also a parent of: Gabo 60; Kentana 48, 51, 52; Lerma 50, 51; and Nainari 60. Florence Aurore, under the name Marroqui, was one of the parents of Yaqui 50, as well as of Mayo 48 and Yaqui 48. (Letter from R. G. Anderson, CIMMYT, February 25, 1974; Brandolini, *op. cit.*; Stakman, *et al., op. cit.*, p. 86, "Nombre, Genealogia y Abreviaturas de Trigos Mexicanos," Ministry of Agriculture and CIMMYT, September 1967, 4 pp.)

[35] Bickel, *op. cit.*, pp. 243–246, 255–256, 259, 274–279; M. S. Swaminathan, "Preface," in *Five Years of Research in Dwarf Wheats*, Indian Agricultural Research Institute, New Delhi, 1968, p. i., also pp. 3–5; Carroll P. Streeter, *A Partnership to Improve Food Production in India,* The Rockefeller Foundation, New York, 1970, p. 12. Also see V. S. Vyas, *India's High-Yielding Varieties Programme in Wheat, 1966–67 to 1971–72*, CIMMYT, 1975, pp. 1–9.

Figure 1. Genealogy of early semi-dwarf CIMMYT wheat varieties[1]



[1] *The presentation of some of the more complex crosses is simplified for graphic purposes. For example, the parentage of Lerma Rojo 64 would be more precisely written as: [(Yaqui 50 x Norin 10-Brevor) Lerma 52] Lerma Rojo[2].*

[2] *Frontana x Kenya 58-Newthatch was bred in Minnesota.*

[3] *From Minnesota.*

[4] *Tezanos Pintos Precoz; from Argentina.*

[5] *Also known as cross 8156; see table 2.*

trainees from Pakistan. The seeds were subsequently planted at the Agricultural Research Institute near Lyallpur. Borlaug visited Lyallpur in the spring of 1963 on the way back from India, and upon his return to Mexico sent 450 pounds of experimental seed. Borlaug visited Pakistan in the spring of 1964 and soon secured governmental and foundation support for the varieties. Pakistan purchased 350 metric tons of Mexican seed for planting during the 1965/66 season and 42,000 tons for the 1967/68 season.[36]

The Mexican varieties proved remarkably adapted to India and Pakistan. The reasons for this are explained by Rao as follows:

- They had been bred in Mexico with alternate generations in different climatic and daylength regimes, primarily in order to get two generations a year. A valuable side effect of this system was to establish a good degree of insensitiveness to photoperiod.

[36] Bickel, *op. cit.* pp. 243, 247–249, 256, 259–265, 274–279. Statistics on the seed purchases are subsequently provided in this report.

• Selection for disease resistance had also been practiced, and the stocks introduced were found to show a remarkable level of resistance under Indian conditions.

• A further important feature of the original stocks was their diversity. They had not been bred to pure line standards, and there remained in them a reservoir of genetic potential that Indian wheat breeders were quick to exploit.[37]

The process of varietal change has gone through four stages in India. The first might be said to be the large imports of seed in the summers of 1965 and 1966. These were composed of Sonora 64 and Lerma Rojo, both with a red grain. The second stage ran through 1970 and consisted of selections made from these and some of the other varieties provided by Borlaug in 1963; the most prominent of the latter group was line 8156. Selection of amber-grained strains was emphasized. Leading varieties were: Sharbati Sonora, Safred Lerma, Kalyan Sona, Sonalika, and Chotti Lerma. The third stage consisted of the development of Indian varieties from materials imported from elsewhere and subsequently selected entirely under Indian conditions. Early varieties in this category were Lal Bahadur, U.P. 301, and Kiran. The fourth stage represented varieties that are being developed from crosses made in India, most frequently involving Indian and CIMMYT-Mexican parents.[38] India is still involved in the third and fourth stages, which include double and triple dwarfs.[39] Disease problems and other difficulties in recent years have led to a renewed emphasis on the development of new varieties.[40]

Details on varieties of Mexican origin or descent used in other developing countries as of 1974 are provided in table 1. Of the many Mexican lines and varieties, offspring of cross 8156 (fig. 1, fn. 5) have been most widely planted. Of the area planted to HYV wheat in India, Pakistan, Afghanistan, and Nepal in 1973, CIMMYT estimates that about 65 percent originated from cross 8156. The proportion in the Middle East and Africa may be as high as 50 percent.[41] Local names which have been used for this cross are provided in table 2.

CIMMYT does not view the development of finished varieties as its main purpose; rather, it provides improved lines to national programs which, in

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[37] M. V. Rao, "Wheat," in *Evolutionary Studies in World Crops; Diversity and Change in the Indian Subcontinent* (ed. by Sir Joseph Hutchinson), Cambridge University Press, 1974, p. 40.

[38] Developed from materials provided in: Streeter, *op. cit.*, pp. 12–17; letter from James H. Boulware, Agricultural Attaché, American Embassy, New Delhi, June 12, 1970; *Evaluation Study of High-Yielding Varieties Programme, Report for the Rabi 1968–69—Wheat, Paddy and Jowar*, Government of India, Planning Commission, Program Evaluation Organization, p. ii; *CIMMYT, 1969–70 Report*, pp. 85–96.

[39] See: Rao, *op. cit.*, pp. 42–43; A. B. Joshi, "Advances in the Development of Improved and High-Yielding Crop Varieties in India and Future Prospects," *Proceedings of the Fourth FAO/Rockefeller Foundation Wheat Seminar* (Tehran, May/June 1973), FAO, Rome, 1974, pp. 180–181.

[40] Richard Critchfield, "India: The Lost Years," *The New Republic*, June 15, 1974; D. V. Khosla, "India's Researchers Seek Higher Yielding Seeds," *Foreign Agriculture*, February 16, 1976, pp. 14, 15.

[41] "Worldwise Use of CIMMYT Bread Wheat Germ Plasm," *CIMMYT Review, 1975*, p. 99.

Table 1—Mexican Bread Wheat Varieties Used in Developing Countries

Variety	Mexican identification	Year released[1]
ASIA (South and East)		
BANGLADESH		
Norteño 67	Norteño 67	74 D
Mexipak 67	Siete Cerros	68 D
INDIA		
Kalyansona	Siete Cerros	67 R
P.V. 18	Super X	
Sonalika	(53-388-AN x Pi "S"-LR)(B4946-A4-18-2 x Y53) Y50[3]	67 R
Chhoti Lerma	LR64 "S"-Hua. R.	67 R
Safed Lerma	Y[50] E-L52/LR	67 R
UP 301	Inia 66 "S"	69 R
Sharbati Sonora	Sonora 64 "S"	67 M
Lerma Rojo 64A	Lerma Rojo 64A	65 D
Sonora 64	Sonora 64	65 D
Lal Bahadur	554723 x R 631-1	69 L
Hira	Pi "S"-Son 64	71 L
Moti	Pi "S" x NP 852	71 L
Janak	Pi "S" x HD 854	73 L
Malavika (durum)	(Pi "S" x TAC125)TA[4] x Z-B Wells x Lakota	73 R
UP 215	Tobari "S"	73 R
Shera	LR64A x Son 64	73 R
HD 2009	LR x Nai 60	74 R
HD 1981	Pi "S" x RN (HD845)	74 R
NEPAL		
Lerma Rojo 64	Lerma Rojo 64	67 D
Sonalika	Sonalika (India)	68 D
Kalyansona	Siete Cerros	67 D
Lerma 52	Lerma 52	53 D
PAKISTAN		
Mexipak 65	Siete Cerros	67 D
Mexipak 69	Siete Cerros	68 R
Indus 66	Super X	66 D
Penjamo 62	Penjamo 62	65 D
Khushal	Cominador x C271	69 L
Tarnab 69	2813 (Y62-63)-C271	69 L
Blue Silver	Sonalika (India)	69 D
Chenab 70	C271-Wt$_E$x Son 64	70 L
Barani 70	Pi "62"-Gb55 x C271	70 L
Green Valley	Chhoti Lerma (India)	70 D
Kalam 71	Combinador x C271	71 L
S.A. 42	C271[2] x LR-Son 64	72 R
NEAR EAST (West Asia, North Africa)		
AFGHANISTAN		
Mexipak	Siete Cerros	68 D
Lerma Rojo	Lerma Rojo	68 D
Bakhtar		72 R
Ephrat		73 D

[1] D = Direct release, R = Reselection, L = Local breeding, M = Mutation.

Variety	Mexican identification	Year released[1]
ALGERIA		
Siete Cerros	*Siete Cerros	72 D
Inia	Inia 66	72 D
Jori (durum)	Jori 69	72 D
Tobari 66	Tobari 66	72 D
Soltane	Soltane (Tunisia)	74 D
EGYPT		
Super X	Super X	71 D
Mexipak	Siete Cerros	72 D
Chenab 70	Chenab 70 (Pakistan)	73 D
S.A. 42	S.A. 42 (Pakistan)	73 D
IRAN		
Inia	Inia 66	68 D
Moghan	LR-NIOB x An^3 E	73 R
Karaj 1	(200H-Vilufen)Roshan	73 L
Arvani 1	Roshan/Mentana-KenyaxMayo 48	73 L
Khazar 1	$P4160_E$-Narino 59 x LR64 A	73 R
IRAQ		
Mexipak	Siete Cerros	67 D
Inia 66	Inia 66	69 D
Jori (durum)	Jori	72 D
JORDAN		
Mexipak	Siete Cerros	69 D
LEBANON		
Mexipak	Siete Cerros	67 D
ARZ	$My54_E$xLR/H490(LR64xTzpp-Y54)	73 R
LIBYA		
Sidi Misri 1	Siete Cerros	72 D
MOROCCO		
Siete Cerros	Siete Cerros	68 D
Tobari	Tobari 66	68 D
Penjamo	Penjamo 62	68 D
Potam 70	Potam 70	72 D
SAUDI ARABIA		
Mexipak	Siete Cerros	69 D
Mexipak Red	Super X	69 D
SYRIA		
Mexipak	Siete Cerros	71 D
Pitic	Pitic 62	68 D
Syrimex	Pi "S" x LR^3	69 R
TUNISIA		
Inia	Inia 66	68 D
Tobari	Tobari 66	68 D
Soltane	Son-Kl. Rend.	74 R

[1] D = Direct release, R = Reselection, L = Local breeding, M = Mutation.

Variety	Mexican identification	Year released[1]
Vaga	Cajeme 71	74 D
Amal (durum)	Brant "S"	74 R
Maghrebi 72 (durum)	Gil "S" (Br180-LK)(GZx61-130)	74 R
Carthage	Np-Tob "S" x 8156	74 R
Dougga	Kl. Pet. Raf. x 8156	74 R
TURKEY		
Mentana	Mentana	63 D
Dicle 74 (durum)	Cocorit 71	74 D
Digueña	(Son64^2 xTzpp-Y54/An64A)Fr^2.Y.Kt.	74 R
AFRICA (excluding North Africa)		
ETHIOPIA		
Laketch	8156 white	70 D
Kenya Kanga	Kenya Kanga (Kenya)	72 D
Supremo-Kenya x Yq48		70 D
KENYA		
Africa Mayo	Africa x Mayo 48	
Kenya Leopard	(Lageadinho x K. 354P^3) x (c. 1.12632 x K354P^3)	66 L
Kenya Kanga	Mexicox [(Wis 245 x Sup. 51)x(Fr-Fn/Y^2). A]	71 L
Trophy 68	T-K^2 x Y50	69 R
Token	T-K^2 x Y50^2	69 R
Kenya Kiboko	C18154-Fr^2 x(Gb54-36896)Gb54	73 L
Kenya Nyati	Romany ^{2} x AfM	73 L
RHODESIA		
Zambesi	8156 x Lee-ND74	66 L
Tokwe	Mex [6xMezoe-ND74]	67 L
SUDAN		
Mexicani	LR-NIOB x An^3 E	71 R
LATIN AMERICA		
ARGENTINA		
Precos Parana Inta	Son 64 x Knott 2	71 R
Marco Juarez Inta	Son 64 x Kl. Rend	72 R
Tala	(Son 64 x Kl. Rend) Mass. 5	73 L
Lapacho	Cno 67 "S"	73 R
CHILE		
Toquifen	C14^4-P4160/Yt^{54} E	69 L
Mexifen	Son 64 x Sk^6 E-An^3 E	71
Quilafen (durum)	Ld357$_E$-Tc^2	61 D
COLOMBIA		
Bonza 63	Rio Negro x Bonza^2	63 L
Tiba	Fr/Y48-My54xMenkemen	63 L
Zipa 68	F-Y 48 x Afm^2	68 R
GUATEMALA		
Nariño 59	Nariño 59	60 D
Pato	Tzpp-Son 64 x Nar 59	71 D
Maya 74	Cno-Gallo	74 R

[1] D = Direct release, R = Reselection, L = Local breeding, M = Mutation.

Variety	Mexican identification	Year released[1]
MEXICO		
Lerma Rojo 64		64 D
Delicias 70		70 D
Siete Cerros 66		66 D
Yecoro 70		70 D
Cajeme 71		71 D
Tanori 71		71 D
Jori 69 (durum)		69 D
Cocorit 71 (durum)		71 D
Jupateco 73		73 D
Torim 73		73 D

[1] D = Direct release, R = Reselection, L = Local breeding, M = Mutation.

Source: "Worldwide Use of CIMMYT Bread Wheat Germ Plasm," *CIMMYT Review, 1975,* pp. 94–97. (The source also provides similar data for developed countries.)

Table 2—Names Used for Cross 8156 in Various Countries.

Red-seeded selection		White-seeded selection	
Name	Country	Name	Country
Super X	México	8156 Blanco	México
Siete Cerros Rojo	México	Siete Cerros 66	México
PV-18	India, Pakistán	Siete Cerros	México
PV-18A	India	7 Cerros 66	México
V-18	India	V-17	India
Indus 66	Pakistán	S-227	India
Mexipak Red	Saudi Arabia, Lebanon	Sona 227	India
MR 548	India	HD 1593	India
NP 323	India	HD 1592	India
CB 90	India	Kalyansona	India
PM 17	India	Kalyansona 227	India
		Kalyan 227	India
		Mexipak = Mxp.	Pakistán, Iraq, Syria
		Mexipak White	Lebanon
		Mexipak-65	Egypt, Lebanon, Pakistan
		Mexipak-69	Pakistan
		Mexi-Pack	Iraq
		Side Misri 1	Lybia
		Laketch	Ethiopia
		Mivhor 1177	Israel
		Hazera 1177	Israel
		Bakhtar	Afghanistan

Source: "Worldwide Use of CIMMYT Bread Wheat Germ Plasm," *CIMMYT Review,* 1975, p. 98.

turn, tailor them to local conditions. The Mexican Government has released a number of varieties and exported substantial quantities of seed.

As noted in Chapter I, most of the HYV wheats discussed in this report are bread wheats. However, considerable research has been carried out by CIMMYT and cooperating agencies to incorporate the Norin 10 dwarfing characteristic (as well as other features) into improved durum varieties. The work was begun in Mexico in the 1950's and, in 1965, the first semi-dwarf durum, Oviachic, was released. The two most widely used varieties as of 1975 were Jori and Cocorit; Jori was named and released by the Mexican Government in 1969 and Cocorit in 1971. In 1975, Mexico released Mexicali. Other varieties are undergoing development in Mexico and in the Middle East. While the Mexican bread wheats initially substituted for durum wheats in some regions in the Near East, this situation may be reversed with the introduction of improved durum varieties. The potential for further yield improvement in durums is considered great.[42]

[42] This section is based on Steven A. Breth, "Durum Wheat: New Age for an Old Crop," *CIMMYT Today,* No. 2, 1975, 16 pp. Further information on HYV durum varieties, comparable to that provided in table 1, will be presented in the *CIMMYT Review, 1976.*

HIGH-YIELDING RICE[1]

The origins of the high-yielding varieties have their roots deep in history and represent a melange of many different efforts and programs.

Chinese Antecedents

China has perhaps the most extended history of rice improvement.[2] As with other countries, much of this was simply farmer selection of improved varieties for local use.

The most significant recorded early step took place sometime before 1000 A.D. when a new group of rices, Champa, was introduced into Fukien from Indochina.[3] After 1012, they were introduced into the lower Yangtze and lower Huai areas. Champa rices had several outstanding features; they were relatively early ripening (60 to 100 days after transplanting) and drought resistant. Although indigenous early-ripening rices had been in use previously, they were quickly replaced by the Champa rices.

Following the introduction of Champa varieties the use of early-ripening rice expanded, especially in southeast China. Other shorter season varieties were developed in the 11th and 12th centuries. By the early 1830's the area under early maturing varieties reportedly exceeded that under traditional types. While most were probably used for early season planting, thereby allowing double cropping, some were used to plant after severe droughts or floods.[4]

The major types of rice grown in China are indica and japonica (or keng). Indicas have traditionally been raised in southern China and japonicas have been grown in more northerly locations.[5] Attempts have been made, both in China (see Chapter III) and in other countries, to improve both types of rice for use in the tropics and other regions.

Japonica Varieties

Breeding of local rices was initiated in Japan early in the 1900's. Successes were obtained in breeding more nitrogen-responsive and disease-resistant types.[6]

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[1] Dr. T. T. Chang of the International Rice Research Institute was of great help in the preparation of this section.

[2] See: Dwight H. Perkins, "Improved Seed," *Agricultural Development in China, 1368-1968*, Aldine, Chicago, 1969, pp. 38-41; Leslie T. C. Kuo, "Seed Selection," *The Technical Transformation of Agriculture in Communist China*, Praeger, 1972, chp. 9, pp. 143-160.

[3] Dr. T. T. Chang has recently placed the point of origin as central Vietnam ("The Rice Cultures," *Philosophical Transactions of the Royal Society of London*, Series B, in press; letter, August 1, 1975).

[4] Ping-ti Ho, "Early Ripening Rice in Chinese History," *The Economic History Review*, December 1956, pp. 200-216. Rice in north China is discussed by Ho in "The Loess and the Origin of Chinese Agriculture," *American Historical Review*, October 1969, pp. 19-26.

[5] T. H. Shen, *Agricultural Resources of China*, Cornell University Press, 1951, p. 197.

[6] Matsuo, *op. cit.* (Chp. I, fn. 15), pp. 20-27, 91-93.

A breeding program to develop daylength- and temperature-insensitive types was initiated in Taiwan in the early 1920's and resulted in the "ponlai" varieties (such as Taichung-65 and Chianan-8).[7] These varieties were early maturing and fertilizer responsive. They made double cropping of a single variety possible and facilitated intercropping.[8] Between 1925 and 1940, 50 percent of the rice land in Taiwan was shifted to the ponlai varieties; by 1974 they represented 85 percent of the area.[9]

Subsequent research verified their high-yielding ability over a wide area in tropical Asia and Africa.[10] But the ponlais did not gain wide commercial acceptance because of disease problems and undesirable grain features.

Japonica X Indica Crosses

An FAO-India program was established in 1950 to cross japonica and indica varieties. Results were generally not satisfactory because nearly all of the japonica parents were from Japan and were poorly adapted to a tropical climate. But one hybrid, ADT-27, did show a substantial improvement over local varieties and subsequently was widely planted in the Tanjore District. This breeding program also produced a few other varieties. One, Mahsuri (Taichung-65 X Mayang Ebos 80/2), was further developed in Malaysia with Japanese assistance and is now extensively planted.[11] Recently, a cooperative project between Korean scientists and the International Rice Research Institute has led to the introduction of Tongil, a cross between IR-8 and (Yukara X TN-1).[12]

Indica Varieties

Attempts to improve indica varieties in the 1940's and 1950's were moderately successful. Results of this work include H-4 and H-5 in Ceylon and Peta, Sigadis, Bengawan, and Remadja in Indonesia.

Taichung Native 1 (TN-1) was developed in Taiwan, named in 1956, and officially released in 1960. It was obtained by crossing Dee-geo-woo-gen, a

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[7] Several of the ponlai varieties included an indica in their parentage. Details on the development of ponlai varieties are provided in E. Iso, *Rice and Crops in Its Rotation in Subtropical Zones,* Japan FAO Association, Tokyo, 1954, pp. 106–137.

[8] C. H. Huang, W. L. Chang, and T. T. Chang, "Ponlai Varieties and Taichung Native 1," *Rice Breeding*, IRRI, 1972, pp. 31–46; letter from Chang, *op. cit.* January 6, 1975.

[9] S. C. Hsieh and V. W. Ruttan, ".... Factors in the Growth of Rice Production.... " *Food Research Institute Studies,* 1967 (No. 3), p. 331; letter from Chang, *op. cit.*, February 23, 1976.

[10] T. T. Chang, "The Genetic Basis of Wide Adaptability and Yielding Ability of Rice Varieties in the Tropics," *International Rice Commission Newsletter*, December 1967, pp. 4–15.

[11] Malinja, another variety developed in the same program and planted in Malaysia, represents a cross between two indicas, Siam 29 and Pebifun. Pebifun originally came from Taiwan where it was once a leading variety. (Letter from Chang, October 27, 1970.)

[12] "IR667-98, A Cool Climate Semidwarf," *The IRRI Reporter*, No. 1, pp. 1–2.

short semi-dwarf variety thought to have come from Fukien Province in southern China several hundred years before,[13] with Tsai-Yuan-Chung, a tall drought-resistant local variety. It was the first semi-dwarf indica to respond to fertilization as well as or better than the ponlais.[14]

TN-1 had its major impact on rice production in India. Jaya and Padma, subsequent Indian varieties, represent a cross of TN-1 and T-141, a tall Indian variety from Orissa.[15] Through 1973, the Indian Council of Agricultural Research had released a total of 16 high-yielding varieties and a number of others were under trial; the most recent releases as of that year were Sona and Jayanti (both of which had superfine grains).[16] In Thailand, a 1964 cross of TN-1 with a local variety (Gam Pai 15/2) produced RD-2, a glutinous variety grown in the Northeast.

These and other HYV's are listed in table 3.

Breeding work in the Philippines was carried out both by the National Government and IRRI. Among the products of the national program, the best known are:[17]

- *BPI-76.* Derived from a cross between Fortuna and Seraup Besar 15. Developed by the Bureau of Plant Industry in 1957 and released in 1960. Strains having less photoperiod sensitivity, such as BPI-76-1 and BPI-76 (n.s.), were released later.
- *C4-63.* Derived from a cross between BPI-76 and Peta. Developed by the College of Agriculture, the University of the Philippines in 1962, released in April 1968. A subsequent selection is known as C4-63G.

The IRRI breeding program began in 1962 and by 1975 released 11 varieties, plus a number of lines which have been named by other agencies and governments (table 3). The major characteristics and resistance ratings of the 11 varieties are outlined in tables 4 and 5. Over time, the varieties have incorporated increased resistance to diseases and insects and greater tolerance to soil problems. Grain quality has also improved.

Peta was included in the ancestry of all 11 IRRI varieties; Dee-geo-woo-gen, in 10.[18] The genealogy of the first six varieties is depicted in figure 2. Additional notes on the 11 varieties follow:[19]

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[13] Noted in T. S. Miu (ed.), *A Photographic Monograph of Rice Varieties of Taiwan*, Taiwan Agricultural Research Institute, Special Publication No. 2, December 30, 1959, p. 67.

[14] See T. T. Chang, *Recent Advances in Rice Breeding in Taiwan*, Joint Commission on Rural Reconstruction, Plant Industry Series 22, 1961, pp. 33–58.

[15] S. V. S. Shastry, "New High-Yielding Varieties of Rice: Jaya and Padma," *Indian Farming*, February 1969, pp. 5–13; Streeter, *op. cit.*, pp. 26, 28.

[16] For details, see: Mahabal Ram, "Ten Years of Dwarf Rice in India," *World Crops*, January/February 1975, pp. 33, 34. Also see *Morphological and Physiological Characteristics of Some High-Yielding Rice Varieties*, IADP Technical Bulletin 9, 1970, 41 pp. (Eluru, India).

[17] Letters from T. T. Chang, January 6, 1975, December 22, 1975.

[18] Peta came from a cross of Tjina × Latisail. Tjina is synonymous with China; Latisail came from Bangladesh. Other varieties produced from the same cross by Indonesian-Dutch breeders in 1940–41 included Mas, Intan, and Bengawan (Z. Harahap, et al, "Breeding Rice Varieties for Indonesia," *Rice Breeding*, IRRI, 1972, p. 142).

[19] In listing the IRRI varieties here and in the remainder of the report, a dash has been inserted between IR and the varietal number in order to maintain consistency with other varietal designations and to improve recognition. IRRI itself does not include this dash in its own publications. Dashes are not inserted in the designation of test lines.

Table 3—HYV Rice Varieties Named from IRRI Lines, Developed from IRRI Crosses by National Programs, or Developed from Crosses Made by National Programs.

(Varieties developed from crosses made by national programs are marked by *.)

Country	Variety	Cross or parental line
ASIA (South and East)		
BANGLADESH	Biplab (BR3)*	IR506-1-133 x Latisail
	Brrisail (BR4)*	IR-20 x IR-5-114-3-1
	Chandina	IR532-1-176
	Irrisail	IR-20
	Mala	IR272-4-1
INDIA[1]	Anupama*	SLO-16 x IR-8
	Aswini*	PTB10 x Dgwg
	Bala*	TN-1 x N22
	Bharathi*	PTB10 x IR-8
	Cauvery*	TN-1 x TKM-6
	CNM25*	IR-8 mutant
	CO-33*	IR-8 x ADT-27
	CO-34*	TN-1 x CO-29
	CO-39*	Culture 340 x Kannagi
	CR34-16*	TN-1 x TKM-6
	CR36-148* (Supriya)	IR-8 x (G.E.B. 24 x TN-1)
	Hamsa*	HR12 x TN-1
	HM95*	Jhona 349 x TN-1
	IET 1039*	CRIO-4103//T90/IR-8
	'IR50'	IR442-2-50
	'IR58'	IR442-2-58
	Jagannath*	mutant from T141
	Jamuna*	TN-1 x Bas. 370/5
	Jaya*	TN-1 x T141
	Jayanti*	IR-8 x T90
	K78*	Shin-ei x Chin 971
	K84	T65 mutant
	Kalinga 1 & 2*	Dunghanshali x IR-8
	Karjat 14-7*	IR-8 x Jiniya 149
	Krishna*	GEB24 x TN-1
	Padma*	T141 x TN-1
	Palman 579	IR579-48-1-2
	Pani Dham 1	IR442-2-24
	Pani Dham 2	IR442-2-58
	Pankaj	IR5-114-3- from Tankai Rotan x Peta
	Pusa 2-21*	IR-8 x TKM-6
	Ratna*	TKM6 x IR-8
	Rohini*	PTB10 x IR-8
	RP-14*	T90 x IR-8
	Sabarmati*	TN-1 x Bas. 370/5
	Sona*	TN-1 x GEB24
	Suma*	TN-1 x TKM-6
	Triveni*	Annapoona x PTB15
	Vaigai*	TN-1 x CO-29
	Vijaya*	T90 x IR-8
INDONESIA	Pelita I/1*& Pelita I/2*	PB5 (IR-5) x Syntha

[1] Does not include all varieties released at the state level.

Country	Variety	Cross or parental line
KOREA (SOUTH)	Tongil	IR667-98 from IR-8 x (Yukara x TN1)
	Yushin	selected from IR1589
MALAYSIA	Bahagia	IR-5-278 from Peta x Tangkai Rotan
	Mahsuri*	(Taichu 65 x Mayang Ebos 80) x M.E. 80
	Masria	IR-8 x Muey Nahng 62M
	Murni*	Bahagia x IR-8
	Pulut Malaysia Satu*	Pulut Sutera x Ria
	Sri Malaysia Dua (II)	IR-8 x Pankhari 203
	Sri Malaysia Satu (I)	IR5-250
NEPAL	Parwanipur I	IR400-29-9-73 from Peta/4 x TN1
PAKISTAN	Abbasi-72	IR841-36-2
	Mehran 69	IR-6 line from Siam 29 x DGWG
PHILIPPINES	BPI-12*	BE3-37-5 (mutant) x IR-20
	BPI-76*	Fortuna x Seraup Besar 15
	BPI-76 (NS)*	selected from BPI-76
	C4 (C4-63)*	Peta x BPI-76
	C4-137*	Peta x BPI-76
	C-168*	Intan x BPI-76
SRI LANKA	BG 3-5*	(Panduruwi x Mas) x Engkatek
	BG11-11*	(Engkatek x H-8) x H-8
	BG34-6*	IR8-246 x [(PP2462/11 x Mas) x H-501]
	BG34-8*	IR8-24-6 x [(PP x Mas) x H501]
	BG90-2*	IR262 x Ramadja
	BG94-1*	IR262 x LD66
	BG96-2*	[IR-8 x (Peta/5 x Belle Patna)] x BG66-1
	IR262	TN-1 x Peta/3
	IR-532	(TN-1 x Peta/3) x TKM-6
	LD66*	H-501 x Dee-geo-woo-gen
	LD125*	IR262 x H-7
	PD106-1*	Warangal 1263 x IR8[3]
TAIWAN	Chianung-sen 6*	IR-8 x TKM6
	Chianung-sen 8	IR661-1-140-3
	Chianung-sen 11* & 12*	IR-8 x IR9-60
THAILAND	RD1*, RD3*	IR-8 x Leuang Tawng
	RD2	TN-1 x Gam Pai 15/2
	RD4*	Leuang Tawng/IR-8 (17-1)// W1252///RD2
	RD5*	Puang Nahk 16 x Sigadis
	RD7*	Gow Ruang 88/C4-63//Sigadis SPR6726-134-2-26
	RD9*	TN-1 2/Leuang Yai 34 (CNT 3176) //W1256///RD2 BKN 6809-74-40
VIETNAM (SOUTH)	TN73-1	IR1529-680-3 from (TN-1 x Sigadis/2) x IR-24
	TN73-2	IR1561-228-3-3 from (IR-8 x Tadukan) x (TKM-6 x TN-1)
NEAR EAST (West Asia, North Africa)		
EGYPT	Sakha 1	IR579-48-1-2
	Sakha 2	IR1561-228-3-3
IRAN	Mehre*	Pureline selection
	70/53*	Dumsiah x IR-8

Country	Variety	Cross or parental line
AFRICA (excluding North Africa)		
IVORY COAST	CS-1	IR262-7-1 from Peta/3 x TN-1
	CS-2	IR160-25 from Nahng Mon S-4 x TN-1
	CS-3	IR253-16-1 from Gam Pai 15/2 x TN-1
	CS-5	IR506-1-36
	CS-6	IR480-14
SIERRA LEONE	ROK-6	IR5-198-1-1
LATIN AMERICA		
BRAZIL	IR665-5-5-5 (?)[2]	IR-8 x (Peta/5 x Belle Patna)
	IR841-63-5 (?)[2]	IR262 x Khao Dawk Mali 4-2-105
COLOMBIA	CICA4	IR930-31-1 from IR-8 x IR12-178
	CICA 6*	IR930-2 x IR822-432
COSTA RICA	CR1113	IR822-81-2 from (IR8/2 x Pankhari 203)
DOMINICAN REPUBLIC	Advance 72	IR930-31-(=CICA-4)
ECUADOR	INIAP-2	IR-22
	INIAP-6	IR930-31-1
EL SALVADOR	Nilo 9	IR160-27-4
	Nilo 11	IR579-48-1
GUYANA	G, J and R	IR1052 cross from BG-79 x IR-8
	K and S	IR1055 cross from BG-79 x IR400-28-4-5
	T*	BG60/283
MEXICO	Bomoa	IR837-46-2 (IR262 x N.S.P.T.)
	Piedras Negras A74	IR837-70-3-6 (IR262 x N.S.P.T.)
	Sinaloa A68	IR160-27-4 from TN-1 x Nahng Mon S-4
	Joachin A-74*	(Corerepe A66[3] x TN-1) x IR160-27-4
	Juchitan A-74	(B572-A3-47-15) x (B589-A4-18-1)
PERU	Chancay	IR930-31-10 from IR-8 x IR12-178
	Naylamp	IR930-2-6
	Huallaga	IR442-2-50 from (TN-1 x Peta/2) x Leb Mue Nahng

[2] Uncertain about local variety name.

Source: Unpublished table compiled by T. T. Chang and associates, International Rice Research Institute, February 23, 1976. Dr. Chang indicates that not all of the varieties may be of commercial importance. The listing reproduced here excludes some varieties used in several South Pacific islands which were included in the original list.

Table 4—Major Characteristics of Varieties Named by IRRI

Character	IR-8	IR-5	IR-20	IR-22	IR-24	IR-26	IR-28	IR-29	IR-30	IR-32	IR-34
Growth duration											
Dry season (Dec. seeding)	125 days	135 days	120 days	115 days	125 days	130 days	105 days	115 days	106 days	140 days	120 days
Wet season (June seeding)	130 days	145 days	135 days	130 days	125 days	130 days	105 days	115 days	109 days	145 days	125 days
Sensitive to photoperiod	no	weakly	weakly	weakly	no	no	no	no	no	no	no
Grain											
Length	medium	medium	medium	long	long	medium	long	medium	medium	long	long
Width	bold	bold	slender	slender	slender	slender	slender	slender	slender	slender	slender
Appearance	some white belly	some white belly	translucent	translucent	translucent	translucent	translucent	opaque	translucent	translucent	some white belly
Head rice recovery	low	moderate	high	high	high	high	high	high	high	high	high
Amylose content	high	high	moderately high	high	low	high	high	waxy	high	high	high
Gel consistency	high	low	medium	high	low	medium-low	high	low	low	low	high
Gelatinization temperature	low	intermediate	intermediate	low	low	low	low	low	intermediate	low	low
Seed dormancy	moderate	moderate	moderate	moderate	moderate	moderate	moderate	moderate	moderate	moderate	high
Seedling vigor	very good	very good	very good	good	good	good	good	very good	very good	very good	very good
Height	90-105 cm	130-140 cm	110-115 cm	95-105 cm	100-110 cm	100-110 cm	100-110 cm	90-100 cm	95-105 cm	100-110 cm	120-130 cm
Tillering ability	high	high	high	high	moderate	high	moderate	high	high	high	high
Lodging	resistant	moderately resistant	moderately resistant	resistant	resistant	moderately resistant	moderately resistant	moderately resistant	moderately resistant	resistant	moderately resistant

Source: *The IRRI Reporter*, No. 4, 1975.

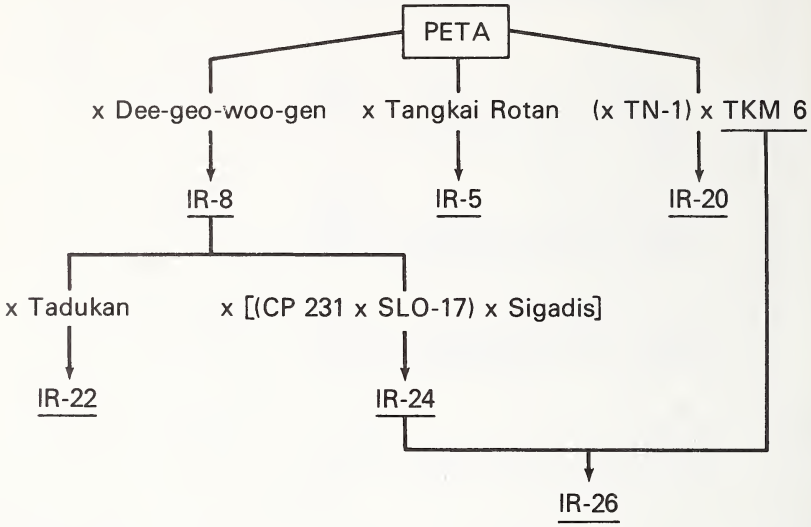
Table 5—Resistance Ratings of IRRI Varieties*

	Diseases				Insects				Soil problems			
Variety	Blast	Bacterial blight	Grassy stunt	Tungro	Green leaf-hopper	Brown plant-hopper	Stem borer	Gall midge**	Alkali injury	Salt injury	Zinc deficiency	Phosphorus deficiency
IR-8	MR	S	S	S	R	S	MS	S	S	MR	S	MR
IR-5	S	S	S	S	R	S	S	S	S	MR	R	MR
IR-20	MR	R	S	R	R	S	MR	S	S	MR	R	R
IR-22	S	R	S	S	S	S	S	S	S	S	S	MR
IR-24	S	S	S	MR	R	S	S	S	MR	MR	S	MR
IR-26	MR	R	MS	R	R	R	MR	S	MR	MR	S	R
IR-28	R	R	R	R	R	R	MR	S	MR	MR	R	R
IR-29	R	R	R	R	R	R	MR	S	S	MS	R	R
IR-30	MS	R	R	R	R	R	MR	S	MR	MR	R	MR
IR-32	MR	R	R	R	R	R	MR	R	S	—	—	—
IR-34	R	R	R	R	R	R	MR	S	S	S	R	R

R = resistant MR = moderately resistant MS = moderately susceptible S = susceptible

*Rated in the Philippines.
**Rated in India.
Source: *The IRRI Reporter*, No. 4, 1975.

Figure 2. Genealogy of early semi-dwarf IRRI rice varieties[1]



[1] *The genealogy of some varieties has been simplified slightly for graphic purposes. IR-20, for instance, originated from a cross between Peta and IR-262-24-3, a descendant of a cross between Peta and TN-1.*

IR-8 was the first of the IRRI semi-dwarf varieties. The initial cross was made in 1962 and the variety was released in November 1966.[20]

IR-5 was developed concurrently and was released in December 1967. It was moderately tall—the tallest of the IRRI varieties.[21]

IR-20 and IR-22 were named in December 1969. Both represented an improvement in grain quality over IR-8 and IR-5.[22]

IR-24 was named in May 1971. It has a low amylose level, meaning that the rice cooks soft and moist.[23]

IR-26 was released in November 1973. It had significantly improved resistance to diseases and insects. The eating quality was slightly better than IR-20.[24]

IR-28, IR-29, and IR-30 were released in January 1975. They are early maturing and have improved resistance ratings. IR-29 is the first IRRI

[20] For details, see Robert F. Chandler, "Dwarf Rice-A Giant in Tropical Asia," *1968 Yearbook of Agriculture,* pp. 252–255; Streeter, *op. cit.,* pp. 26–29.

[21] Further information is provided in "IR-5-A New High-Yielding IRRI Variety," *IRRI Reporter,* January 1968, 4 pp.

[22] The aditional information is found in "IR-20 and IR-22, New Rice Varieties," *The IRRI Reporter,* January 1970, 4 pp.

[23] Further details are presented in: "IR-24-A Low Amylose Variety," *The IRRI Reporter,* No. 2, 1971, pp. 1–2; and the *IRRI Annual Report for 1971,* p. 182.

[24] Further details are provided in "IR-26 is Resistant to Brown Planthoppers," *The IRRI Reporter,* No. 4, 1973, pp. 1–2.

variety to have a glutinous or waxy grain; this type of rice cooks soft and sticky, is the staple food in Laos and northeast Thailand and is used in special preparations such as cakes and pastries across Asia.[25] The parentage of these varieties is:

- IR-28 and IR-29: Peta[3]/TN-1//Gam Pai 15/4/IR-8/Tadukan//TKM-6[2]/TN-1///IR-24[4]/*Oryza nivara.*
- IR-30: IR-24/TKM 6//IR-20[3]/*Oryza nivara.*

IR-32 and IR-34 were released in July 1975. They have some characteristics which may adapt them to rainfed areas where the previous IRRI varieties were not as well suited. This is desirable in some regions, where farmers grow only one crop, so that harvesting and drying can be done after the monsoon rains. IR-32 matures later (140 to 145 days) than the other IRRI semidwarfs. IR-34 is intermediate in height and may be suited for regions where water becomes rather deep for semi-dwarfs during the monsoon regions. Both have improved disease and insect resistance, but are less tolerant of certain soil problems.[26] The parentage of these varieties is:

- IR-32: IR 20[2]/*Oryza nivara*//CR 94-13.
- IR-34: Peta[3]/TN 1//Gam Pai 15/4/IR 8/Tadukan//TKM 6[2]/TN-1///IR 24[4]/*Oryza nivara*

As of November 1975, IRRI stopped its practice of naming varietal releases. Instead, the naming of varieties will be left to national organizations and programs. In the Philippines, the Philippines Seed Board will continue to use an IR designation for IRRI selections released in that country.[27]

Clearly, a wide range of characteristics and crosses have now been developed from a few original varieties. More are currently under development and will appear in the future.

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The specific wheat and rice varieties which have been outlined in this chapter will reappear in the footnotes of many of the country tables in the next two chapters. It was not possible to obtain a complete varietal breakdown for each country, but such information is included where reported.

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[25] "IRRI Names Three Early Maturing Rices with Disease and Insect Resistance," *The IRRI Reporter,* 1/75, pp. 1–3. (News release issued January 10, 1975.)

[26] "IRRI Names Two New Rice Varieties," *The IRRI Reporter,* 4/75, pp. 1, 4. (News release issued July 21, 1975.)

[27] "IRRI Announces New Policy on Naming of Rice Varieties," *The IRRI Reporter,* 1/76, p. 1.

III. HIGH-YIELDING WHEAT VARIETIES

This chapter summarizes available data on the area of high-yielding varieties of wheat planted or harvested and fragmentary information on seed imports by developing nations in Asia (South and East), the Near East (West Asia and North Africa), Africa, and Latin America. Separate tables are provided for most of the Asian and Near Eastern countries. The scattered data for other nations, where available, are summarized in brief notes.

The tables provide annual data on major seed imports and the HYV area planted or harvested. Further details are presented in footnotes. A reference is provided for each statistic cited. Data which are particularly tentative or are preliminary estimates for 1975/76 are placed in parentheses. Statistics are generally rounded to the nearest hundred; consequently, the hectare and acre figures do not convert precisely.

The parentage of many of the varieties mentioned in this chapter is summarized in table 1 in Chapter II. Details on the breeding programs in many of the countries are presented in the CIMMYT annual reports (the *CIMMYT Wheat Report* for the period from 1973 to the present).

Semi-dwarf wheat has been raised in a number of developed countries. In the United States, a relatively short-strawed (but not semi-dwarf), earlier maturing wheat was first introduced in 1794 (Chapter II), and again in 1940.[1] The first semi-dwarf variety, Gaines, was developed from a Norin 10 x Brevor cross by Dr. O. A. Vogel (Chapter II) and released in 1961. Other semi-dwarf varieties were subsequently released in several States, and Mexican varieties were introduced.[2] By 1970, significant areas were planted to semi-dwarfs in five western States.[3] By 1975, the semi-dwarf area in this region increased even more and two north-central States were added: North Dakota and Minnesota.[4] Altogether, perhaps one quarter or more of the

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[1] L. W. Briggle and O. A. Vogel, "Breeding Short-Stature, Disease-Resistant Wheat in the United States," *Euphytica,* Supplement No. 1, 1968, p. 108.

[2] *Ibid.*, pp. 110, 114–125; L. P. Reitz and S. C. Salmon, "Origin, History, and Use of Norin 10 Wheat," *Crop Science,* November-December 1968, pp. 686–687. While most of the varieties trace this dwarfing characteristic to Norin 10, a Korean variety, Suwon 92, has also been used.

[3] L. P. Reitz, K. L. Lebsock and G. D. Hasenmyer, *Distribution of the Varieties and Classes of Wheat in the United States in 1969*, U.S. Department of Agriculture, Agricultural Research Service, Statistical Bulletin No. 475, May 1972, pp. 14, 15. The semi-dwarfs probably accounted for over 75 percent of the area in Arizona and California in 1970 and over 50 percent in Oregon, Washington, and Idaho. Additional areas were planted to short varieties in other States.

[4] Based on phone discussions with wheat breeders in a number of States. Virtually all of the wheat area in Arizona and California was believed to be planted to

U.S. wheat area was planted to semi-dwarfs in 1975.[5] Further expansion is likely. No attempt has been made to detail such progress in the developed nations in this report.

ASIA

HYV wheat has found major adoption in South Asia, particularly in India and Pakistan. It is also raised in Nepal. The area in Bangladesh is limited but is expected to increase substantially. Most of the land sown to the HYV's in South Asia is irrigated to some degree.

The HYV wheat area in non-Communist East Asian LDC's, where wheat is of minor overall importance compared to rice, appears to be negligible. Burma imported about 1.5 metric tons (M.T.) of Indian HYV seed in 1969/70, but it is not known what came of it. Japan, the home of Norin 10 wheat, is excluded from this report because of its status as a developed nation.

Both North Vietnam and the People's Republic of China (PRC) have imported significant quantities of HYV seed. North Vietnam imported 1,000 M.T. of Sonalika seed from India in 1972/73. The PRC's imports of Mexican seed are discussed separately in this section. Mongolia also imported small quantities of Indian seed in 1974/75 and 1975/76.[6]

But while there appears to be considerable interest in the HYV wheats in Communist Asia, it is in India and Pakistan where they have been most widely adopted to date.

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semi-dwarfs, while the percentages in other States were about as follows: Oregon, 70; Washington, 75; Idaho, 70; North Dakota, 30; Minnesota, 80.

[5] Based on discussions with James Naive, Economic Research Service, U.S. Department of Agriculture, February 1976. The inclusion of short-strawed varieties in other States would raise the figure even higher.

[6] Data on seed imports from India provided by Robert C. Tetro, Jr., Assistant Agricultural Attaché, American Embassy, New Delhi, November 28, 1975.

Table 6—Bangladesh: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1968/69	–	8,400	20,800 (3)
1969/70	–	9,100	22,500 (3)
1970/71	–	13,500	33,400 (3)
1971/72	–	15,000	37,000 (4)
1972/73	50[1] (1)	21,450	53,000 (4)
1973/74	1,000[2] (1)	29,100	72,000 (5)
1974/75	320[3] (1)	33,200	82,000 (5)
1975/76	4,075[4] (1) (2)	(95,000)	(235,000)[5] (6)

[1] Kalyan Sona from India.
[2] 700 M.T. of Sonalika and 300 M.T. of Kalyan Sona from India.
[3] 150 M.T. of Sonalika and 170 M.T. of Kalyan Sona from India.
[4] 2,775 M.T. of Sonalika from India; 1,200 M.T. of Tanori 71 from Mexico; and 100 M.T. of foundation seed (40 tons of of Tanori 71, 30 tons of Jupa Tico, and 30 tons of Nuri) from Mexico (provided by FAO).
[5] Unofficial estimate as of early 1976. The planned area under the "Accelerated Cereal Production Program" was 80,900 ha. (200,000 acres) (ref. 5).

References

(1) Table provided by Robert C. Tetro, Acting Agricultural Attaché, American Embassy, New Delhi, November 28, 1975 (data provided by National Seeds Corporation).
(2) Shafial Alam, "Notes on the HYV Wheat and Rice," Office of Agricultural Attaché, American Embassy, Dacca, December 1975.
(3) Foreign Agricultural Service Report BD-3012 from Dacca, April 18, 1973 (based on statistics provided by the Bureau of Agricultural Statistics, Directorate of Agriculture).
(4) Letter from Carl O. Winberg, Agricultural Attaché, American Embassy, Dacca, October 15, 1973.
(5) Data compiled by Shafial Alam, *op. cit.* Similar data are cited for these years, as well as back to 1968/69, by Stephen D. Biggs and Edward J. Clay, "Wheat in Bangladesh; An Economic Analysis of Past, Present, and Future Development," Ford Foundation and Agricultural Development Council, Dacca, August 1975, Table A 2.
(6) Letter from R. Glenn Anderson, CIMMYT, March 17, 1976 (following trip to Bangladesh).

Table 7—India: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested		
	Metric tons	*Hectares*	*Acres*	
1965/66	250[2] (1) (2)	3,000	7,400	(3)
1966/67	18,000[3] (1) (2)	540,000	1,336,600[4,5]	(4)
1967/68	–	2,942,000	7,269,700[4,5]	(4)
1968/69	–	4,792,700	11,842,800[4,5]	(4)
1969/70		5,004,900	12,367,200[4]	(4)
1970/71	–	6,542,500	16,166,400[4]	(4)
1971/72	–	7,858,100	19,417,500[4]	(4)
1972/73	–	10,007,000	24,727,300[4,6]	(5)
1973/74	–	10,911,000	26,961,100[4,6]	(5)
1974/75	–	11,778,400	29,104,400[4,6]	(5)
1975/76	–	(12,600,000)	(31,134,600)[7]	(5)

[1] See Chapter II (wheat) for a discussion of the evolution of Mexican varieties in India.
[2] 200 M.T. of Sonora 64 and 50 M.T. of Lerma Rojo 64.
[3] Mostly Lerma Rojo 64; remainder, Sonora 64.
[4] The distribution of this area by State was:

	Uttar Pradesh	*Punjab*	*Bihar*	*Haryana*	*Other*	*Total*
	Percent					
1966/67	67	11	5	3	15	100
1967/68	54	22	6	3	15	100
1968/69	53	21	6	5	15	100
1969/70	33	30	9	9	20	100
1970/71	30	24	14	10	23	100
1971/72	28	22	15	10	25	100
1972/73*	31	19	16	10	24	100
1973/74*	31	18	15	9	27	100
1974/75*	33	16	14	9	29	100

*Preliminary

[5] Includes improved local varieties (ref. 6).
[6] Most popular varieties include Kalyansona and Sonalika. CIMMYT has indicated that as of 1973, Kalyansona accounted for about 48 percent of the HYV area and Sonalika for about 22 percent; other major varieties were Chhoti Lerma, Safred Lerma, U.P. 301, and Lerma Rojo 64A (ref. 7).
[7] Target.

References

(1) *Rice and Wheat in India.* Spring Review (AID), March 10, 1969, p. 7.
(2) *Five Years of Research on Dwarf Wheat,* Indian Agricultural Research Institute, New Delhi, 1968, Preface; Grant Cannon, "On the Eve of Abundance," *Farm Quarterly,* Fall Forecast, 1967, pp. 89–90.
(3) *1966/67 CIMMYT Report,* p. 67.
(4) Foreign Agricultural Service Report IN-5027 from New Delhi, May 14, 1975.
(5) Data provided by Ivan E. Johnson, Agricultural Attaché, American Embassy, New Delhi, January 2, 1976.
(6) V. S. Vyas, *India's High Yielding Varieties Programme in Wheat, 1966–67 to 1971–72,* CIMMYT, 1975, pp. 5, 7.
(7) *CIMMYT Review, 1975,* p. 94.

Table 8—Nepal: HYV Wheat

Crop year	Quantity of seed imported		Area planted or harvested	
	Metric tons		*Hectares*	*Acres*
1965/66			1,400	3,500[8] (1)
1966/67	38[1]	(1)	6,600	16,200[9] (1)
1967/68	450[2]	(1)	24,800	61,300[10] (1)
1968/69	7[3]	(2)	53,800	132,900[11] (2)
1969/70	300[4]	(2)	75,500	186,600[11] (2)
1970/71	136.5[5]	(2)	98,200	242,700[11] (2)
1971/72	1,200[6]	(3)	115,900	286,450[11] (3)
1972/73	1,638[7]	(3)	170,300	420,700[12] (3)
1973/74	—		206,800	511,000[12] (4)
1974/75	—		246,900	610,000[12] (4)

[1] Lerma Rojo. Imported from Mexico by India.
[2] Lerma Rojo, from India.
[3] S-331 from India.
[4] S-227 from India.
[5] 136 M.T. of S-227 from India and 0.52 M.T. Chenab-70 from Pakistan.
[6] 950 M.T. of S-227; 100 M.T. of RR-21; and 150 M.T. of S-331. All from India.
[7] 915 M.T. of RR-21; 300 M.T. of RR-21 foundation seed; 390 M.T. of S-227; 30 M.T. of UP 301; and 3 M.T. of S-331. All from India.
[8] Lerma 52.
[9] Lerma 52 (91.4 percent) and Lerma Rojo (8.6 percent).
[10] Lerma 52 (31.6 percent) and Lerma Rojo (29.7 percent).
[11] All improved wheat planted.
[12] Kalyansona, RR-21, LR-52, LR-64, S-227, S-331, and UP-301.

References

(1) Department of State Airgram TOAID A-404 from Kathmandu, February 16, 1968.
(2) Letter from Raymond E. Fort, Food and Agriculture Division, USAID Kathmandu, October 13, 1971 (data from Economic and Planning Division, Ministry of Food and Agriculture).
(3) Letter from Philip D. Smith, Chief, Food and Agriculture Division, USAID, Kathmandu, October 17, 1973 (seed import data from the Agricultural Marketing Corporation; HYV area from Department of Agriculture).
(4) Letters from John R. Wilson, Chief, Food and Agriculture Division, USAID, Kathmandu, October 9, 1975, February 25, 1976 (data from Department of Agriculture).

Table 9—Pakistan: HYV Wheat

Grop year	Quantity of seed imported	Area planted or harvested		
	Metric tons	*Hectares*	*Acres*	
1965/66	350[1] (1) (2)	4,900	12,000	(1)
1966/67	50[2] (1) (2)	101,200	250,000	(1)
1967/68	42,000[3] (1) (2)	957,100	2,365,000	(3)
1968/69	—	2,387,700	5,900,000	(4)
1969/70	—	2,681,500	6,626,000[5]	(5)
1970/71	—	3,128,300	7,730,000	(6)
1971/72	—	3,286,200	8,120,000[6,7]	(6)
1972/73	—	3,375,200	8,340,000[6]	(7)
1973/74	—	3,472,300	8,580,000[6,8]	(7)
1974/75	—	(3,682,800)	(9,100,000)[9]	(8)
1975/76	12,000[4] (9) (10)			

[1] 250 M.T. of Penjamo 62 and 100 M.T. of Lerma Rojo 64.

[2] Mostly Mexipak 65 (white—Siete Cerros); some Mexipak Red (Indus 66). In addition, 20 M.T. were available locally.

[3] 40,000 M.T. of Mexipak Red (Indus 66) and 2,000 M.T. of Mexipak 65 (Siete Cerros).

[4] Average of two estimates, one of 11,683 M.T. (ref. 9), and another of 12,476 M.T. (from Mexico) (ref. 10). Earlier expectations were for imports of 17,000 M.T. from Mexico, of which 56.6 percent was to be Yocora and 38.8 percent Nuri (ref. 7).

[5] Of the total area, about 81 percent was Mexipak, 12.5 percent Indus 66, 4 percent Norteno 67, and 1 percent Inia 66 (ref. 11).

[6] The distribution of this area by province was:

	Punjab	*Sind*	*NWFP*	*Baluchistan*	*Total*
			Percent		
1971/72	75	16	8	1	100
1972/73	74.8	15.6	9.1	0.5	100
1973/74	76.4	16.2	8.7	0.5	100

[7] Mexipak continued to be the dominant variety. Newer varieties being grown extensively included Pakistan 20, Chenab 70, Barani 70, SA-42, Khushal 60, and Khushal 69 (ref. 12).

[8] Three improved varieties developed at Lyallpur were released to growers in the fall of 1973: Sandal, Lyallpur-73, and Pari. A new variety, Potohar, was released in 1974 for barani growing conditions.

[9] Unofficial estimate.

References

(1) *Rice and Wheat in Pakistan*, Spring Review (AID), March 17, 1969, pp. 3-5.
(2) *1966-67 CIMMYT Report,* pp. 64-65; Cannon, *op. cit.*, p. 90.
(3) "Country Field Submission: Pakistan, FY 1971," AID, August 1969, Appendix A, Table 1.
(4) Foreign Agricultural Service Report PK-0003 from Rawalpindi, January 20, 1970, p. 4.
(5) Foreign Agricultural Service Telegram TOFAS 02 from Islamabad, January 5, 1972.

(6) Data provided by S. M. A. Jafri, Statistical Officer, Planning Unit, Ministry of Agriculture and Works, Agriculture Wing, Islamabad, December 5, 1973.
(7) Letter from Alvin E. Gilbert, Agricultural Attaché, American Embassy, Islamabad, October 2, 1975. The 1972/73 and 1973/74 data were obtained from the Planning Unit of the Ministry of Agriculture.
(8) Foreign Agricultural Service Telegram TOFAS 11 from Islamabad, February 20, 1976.
(9) Foreign Agricultural Service Report PK-6004 from Islamabad, February 25, 1976, p. 1.
(10) Letter from Richard S. Welton, Agricultural Attaché, American Embassy, Mexico City, March 10, 1976 (refers to Mexican exports to Pakistan in 1975; may include some seed for Bangladesh).
(11) *1969-70 CIMMYT Report,* p. 90.
(12) *CIMMYT Annual Report, 1972*, p. 50.

People's Republic of China

The Mexican wheats are well known to the People's Republic of China (PRC). Several years of small-scale testing were reportedly carried out in the early 1970's using experimental samples obtained from Australia and Pakistan.[1] In 1973, a visiting Mexican scientist found all the Mexican dwarf wheats released since 1960 growing in PRC research stations. In October of the same year, the PRC Embassy in Mexico sent two staff members to CIMMYT to discuss research work and collect publications.[2]

The PRC has imported the following quantities of Mexican wheat seed: 1972, 2 M.T.; 1973, 5,034 M.T.; and 1974, 14,701 M.T.[3] The most recent shipments, those intended for planting in the fall of 1974 and the spring of 1975, were broken down as follows (in percent): Potam, 61.6; Tanori, 24.7; Saric, 7.0; Inia, 3.5; and Jori, 3.5.[4]

According to a visiting delegation of U.S. plant scientists (including Dr. Borlaug) in the fall of 1974:

> The introduction of the early maturing, high-yielding Mexican wheat varieties . . . has permitted expansion of fall-sown spring wheats into areas in the south where little or no wheat was formerly planted. Most of this anticipated expansion will be in the southern part of the conventional winter wheat belt, and in areas farther south, such as Hupei, Hunan, Kiangsi, Chekiang, Kwangsi, and Kwangtung. There are other local areas farther north where the Mexican type of spring wheat may be used successfully.[5]

Another account has suggested that in the subtropical areas wheat is increasingly being sown after the late rice crop has been harvested in the fall. More than 6,000 ha. (15,000 acres) were reportedly planted to Mexican wheats in Kwangtung Province in 1973.[6]

A CIMMYT official visiting China in November 1975 was told by an authoritative source that most of the Mexican varieties had proven to be too late in maturing and were not sufficiently resistant to local diseases. They were, however, being extensively used in crosses with native varieties.[7]

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[1] *Plant Studies in the People's Republic of China*, A Trip Report of the American Plant Studies Delegation, National Academy of Sciences, Washington, 1975, p. 56.

[2] Letter from Haldore Hanson, Director, CIMMYT, January 17, 1974.

[3] Letters from Richard A. Smith, Agricultural Attaché, American Embassy, Mexico City, January 18, 1974 (data from the Director General of Statistics, Secretariat of Industry and Commerce), August 29, 1975.

[4] *Plant Studies. . . , op. cit.*, p. 56. The total quantity referred to in this report was 15,750 M.T.

[5] *Ibid.* Also noted by G. F. Sprague in "Agriculture in China," *Science*, May 9, 1975, p. 553.

[6] "PRC Sows Mexican Wheat Varieties," *Foreign Agriculture* (USDA), October 20, 1975, p. 13.

[7] Interview with Haldore Hanson of CIMMYT, Washington, April 14, 1976.

NEAR EAST

The Near East is defined in this report as West Asia and North Africa. It is a rather diverse region geographically. While HYV wheat is largely raised under irrigation in West Asia and Egypt, it is more often raised under rainfed conditions in the remainder of North Africa and Turkey. Winter wheat and durum wheat are also grown in some of the countries.

Throughout the region there is a relative scarcity of statistics on the HYV area. Severe data shortages exist for several countries, particularly Turkey. Where the HYV data do exist, they sometimes do not adequately differentiate between varieties.

Despite these difficulties, at least partial statistics are presented for 15 countries. Israel is considered a developed country and is not included.[1] Several developing countries are omitted because of data problems, including Cyprus[2] and Jordan[3]. Small areas of HYV wheat may also be planted in other countries such as Libya, Oman, and Yemen, but no specific area estimates were found.

It may be of historical interest to note that the dwarf wheats were first introduced to the Near East in 1963. In that year a former student of Borlaug grew the new Mexican varieties at a station north of Cairo. Egyptian use of the varieties, however, was very limited until the early 1970's.[4]

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[1] For details on the use of HYV's in Israel, see Yoav Kislev and Michael Hoffman, "Research and Productivity of Wheat in Israel," Hebrew University, Center for Agricultural Economic Research, Rehovot, February 1975, 22 pp.

[2] In the 1973 period, about 14,000 ha. (35,000 acres) were reportedly planted to the Mexican-type varieties, principally Pitic 62, on Cyprus (letter from Abdul Hafiz, Project Manager, Regional Field Food Crops Project, Food and Agricultural Organization, Cairo, December 6, 1973).

[3] Jordan was included in previous editions of this report, but was dropped from this edition because the varietal data do not differentiate betweem improved local and Mexican varieties. The main HYV is Mexipak. The total area of improved and high-yielding varieties in any case, was rather small—about 7,000 ha. in 1974/75. (Letter from John Hyslop, USAID, Amman, February 22, 1976.)

[4] Lennard Bickel, *Facing Starvation; Norman Borlaug and the Fight Against Hunger,* Readers Digest Press, 1974, pp. 246, 247, 249.

Table 10—Afghanistan: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1965/66	50[1] (1)	–	–
1966/67	420[2] (2) (3)	1,800	4,500[6] (6)
1967/68	–	22,000	54,400 (7)
1968/69	–	122,000	301,500 (7)
1969/70	–	146,000	360,800 (8)
1970/71	–	232,000	573,200 (9)
1971/72	6,000[3] (4)	255,000	630,000 (9)
1972/73	2,000[4] (5)	450,000	1,112,000 (9)
1973/74	500[5] (5)	475,000	1,173,700 (5)
1974/75	–	522,000	1,289,900[7] (5)

[1] Lerma Rojo 64A. Imported from Mexico in 1965.
[2] Lerma Rojo 64: 250 M.T. from Mexico (ref. 2), and 170 M.T. from Pakistan (ref. 3).
[3] Mexipak from Pakistan; 2,000 M.T. certified, 4,000 M.T. uncertified. As of December 1971, the certified seed had been received and planted; the uncertified seed was received in time for spring planting (some lots, however, were reported to have low germination and to be weevily). These imports were stimulated by a prolonged drought.
[4] Bezostaya.
[5] Kafqaz (Russian variety).
[6] Of this total, nearly 800 ha. (2,000 acres) were Lerma Rojo 64A and 768 ha. (1,900 acres) Tascosa.
[7] Mexipak is the primary spring wheat variety; Bezostaya is the leading winter variety (ref. 10).

References

(1) "The Green Revolution," *Participant Report*, USAID, Kabul, Summer 1969, p. 2.
(2) *Fourth Annual Wheat Seminar, August 28, 1969—September 8, 1969*, Ministry of Agriculture and Irrigation, Kabul; summary paper by Joe Motheral.
(3) *CIMMYT Report, 1967-68*, pp. 59, 72.
(4) Letters from John R. Wilson, Food and Agriculture Officer, USAID, Kabul: November 27, 1971; November 17, 1973.
(5) Letter from Ernest J. Barbour, Chief, Public Administration—Rural Development, USAID, Kabul, September 28, 1975.
(6) *Agricultural Development in Afghanistan, with Special Emphasis on Wheat*, U.S. Agricultural Review Team, July 1967, pp. 31-32.
(7) Department of State Airgram TOAID A-574 from Kabul, December 8, 1969, p. 8 (Table III).
(8) Letter from Joe R. Motheral, Food and Agriculture Officer, USAID, Kabul, September 23, 1970.
(9) Letters from Wilson, *op. cit.*, October 24, 1973, November 17, 1973.
(10) Letter from R. Glenn Anderson, CIMMYT, September 19, 1975.

Table 11—Algeria: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1969/70	1,500[1] (1)	5,100	12,600 (4)
1970/71	17,000[2] (2)	140,000	346,000[4] (2)
1971/72	—	320,000	790,700[5] (4)
1972/73	15,468[3] (3)	600,000	1,482,600[6,7] (5) (6)
1973/74	—	NA	NA
1974/75	—	NA	NA[8]

[1] Principally from Mexico. Substantial quantities of seed were also imported from Morocco and Tunisia.

[2] In 1970, Mexico exported 11,182 M.T. of seed to Algeria; the business was handled by a Swiss firm, however, and the exports are listed as going to Switzerland in the official Mexican statistics (ref. 7).

[3] Reported export of seed from Mexico to Algeria in 1972.

[4] Seed supplies were sufficient for 48,000 ha. (365,700 acres), but some arrived late. About 138,000 ha. (341,000 acres) were planted to Mexican varieties (Inia 66, Siete Cerros, and Tobari) and 2,000 ha. (4,940 acres) to Italian varieties.

[5] Inia 66, Siete Cerros, Tobari, and Strampelli.

[6] Principally used in the socialist sector.

[7] About 80 percent bread wheats and 20 percent durums. Within the bread category the varietal breakdown was: Siete Cerros 70 percent, Inia 25 percent, and Tobari 5 percent. The durum variety was Jori C69. Strampelli performed as well as Siete Cerros, but was still under seed multiplication.

[8] In terms of HYV composition, Siete Cerros continued to be the leading bread variety while Cocorit was the leading durum variety (ref. 8).

References

(1) Conversation with Dr. Gregorio Martinez of CIMMYT, December 17, 1970.
(2) *CIMMYT Annual Report, 1970/71*, p. 51.
(3) Letter from Richard A. Smith, Agricultural Attaché, American Embassy, Mexico City, January 18, 1974 (data from Director General of Statistics, Secretariat of Industry and Commerce).
(4) *CIMMYT Annual Report, 1972*, p. 70.
(5) Zhor Zerari, "Cereal Production Set Back by Bad Weather" (in French), *Algerie-Actualite,* Algiers, July 1973, p. 8.
(6) Letter from W. L. McCuistion, Project Cereales-CIMMYT, Algiers, January 28, 1974.
(7) Letter from John D. Jacobs, Assistant Agricultural Attaché, American Embassy, Mexico City, February 12, 1974.
(8) Letter from R. Glenn Anderson, CIMMYT, February 10, 1976.

Table 12—Egypt: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested		
	Metric tons	*Hectares*	*Acres*	
1970/71	–	150	400[1,2]	(1)
1971/72	–	1,800	4,500[1,2]	(1)
1972/73	–	20,100	49,700[1]	(1)
1973/74	–	212,800	525,800[1]	(1)
1974/75	–	78,600	194,200[3]	(1)
1975/76	–	(60,700)	(150,000)[4]	(2)

[1] Principally Mexipak (Siete Cerros); some Super X. Chenab-70 appears to have been released in 1972/73.

[2] Seed multiplied on Ministry of Agriculture farms in 1969/70 and released to agrarian reform farms in 1970/71 and other farmers in 1971/72 (ref. 3).

[3] Reasons for this drop included: (a) Government policies which required forced delivery of three ardebs for every feddan planted instead of the two required for traditional varieties; and (b) shattering, grain color, and baking and milling qualities (refs. 1, 2, and 4). The latter problems are expected to be countered through increased use of Chenab-70 (ref. 2).

[4] Preliminary and unofficial estimate. About one third of the HYV area is planted to Chenab-70, which is expected to increase fourfold during 1976/77.

References

(1) Letter from R. Gerald Saylor, The Ford Foundation, Cairo, October 29, 1975 (data from the Institute of Agricultural Economics, Ministry of Agriculture).
(2) Letter from Gordon W. McLean, The Ford Foundation, Cairo, March 22, 1976.
(3) H. A. El-Tobgy, *Contemporary Egyptian Agriculture,* The Ford Foundation, Beirut, January 1974, p. 96.
(4) John Waterbury, "'Aish: Egypt's Growing Food Crisis," American Universities Field Staff, Fieldstaff Reports, Northeast Africa Series, Vol. 19, No. 3, December 1974, p. 5; Richard Critchfield, "Egypt Plunges Into Green Revolution," *Christian Science Monitor,* January 20, 1975.

Table 13—Iran: HYV Wheat

Crop year	Quantity of seed imported		Area planted or harvested		
	Metric tons		*Hectares*	*Acres*	
1968/69	1,500[1]	(1)	10,000	25,000[3]	(3)
1969/70	4,000[2]	(2)	37,000	91,400[3]	(3)
1970/71	—		63,000	155,700[3]	(3)
1971/72	—		125,000	308,900[3]	(3)
1972/73	—		138,000	341,000[3,4]	(3)
1973/74	—		(261,000)	(644,900)[5]	(4)

[1] Penjamo 62 imported from Turkey.

[2] About 2,500 M.T. of Bezostaya No. 1 from USSR and 1,500 M.T. of Mexican Inia 66 from Denmark. Of the Bezostaya seed, 500 M.T. were planted during the 1969/70 season and 2,000 M.T. during the 1970/71 season (ref. 5).

[3] Mexican varieties. In addition, the following area was planted to other varieties:

	Bezostaya	*Improved local*	*Total*
		Hectares	
1968/69	—	25,000	25,000
1969/70	5,000	NA	5,000
1970/71	15,000	22,000	37,000
1971/72	38,000	120,000[a]	158,000
1972/73	34,000	126,000[a]	160,000

[a] Principally Roshan and Omid.

[4] In 1972/73, five new varieties, several with Mexican parentage, were released: Karaj 1, Karaj 2, Arvani 1, Khazar 1, and Moghan 1. About 200 M.T. of Moghan were available for distribution. (Ref. 6).

[5] Unofficial estimate based on assumption that 45 percent of the total improved wheat area was planted to Mexican varieties (the Mexican proportion was 44.2 percent in 1971/72 and 46.3 percent in 1972/73).

References

(1) Foreign Agricultural Service Reports from Tehran: IR-9003, January 20, 1969; IR-9006, February 5, 1969.
(2) Foreign Agricultural Service Report IR-0018 from Tehran, October 8, 1970.
(3) H. Kaveh, "Iran," *Proceedings of the Fourth FAO/Rockefeller Foundation Wheat Seminar* (Tehran, May/June 1973), FAO, Rome, 1974 (AFP:FC/21), p. 72.
(4) Foreign Agricultural Service Telegram TOFAS 26 from Tehran, February 17, 1976.
(5) Letter from Dale K. Vining, Agricultural Attaché, American Embassy, Tehran, December 29, 1973.
(6) *CIMMYT Report on Wheat Improvement, 1973*, p. 78.

Table 14—Iraq: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1965/66	5[1] (1)	–	–
1966/67	–	–	–
1967/68	800[2] (2)	6,400	15,800[1] (1) (4)
1968/69	–	41,700	103,000[1] (1)
1969/70	–	195,200	482,400[1] (1)
1970/71	–	125,000	309,000[1] (4)
1971/72	70,000[3] (3)	950,000	2,347,500[4,5] (3)
1972/73	–	595,000	1,470,200[4,6] (5)
1973/74	–	700,000	1,729,700 (5)
1974/75	–	750,000	1,853,300[7] (5)

[1] Mexipak.
[2] Mexipak shipped from West Pakistan, September 1968.
[3] Mexican varieties imported in response to a drought-induced crop failure in 1970/71. According to Mexican sources, 61,000 M.T. of seed wheat were shipped to Iraq in 1971 (the business was handled by a Swiss firm and the exports are listed as going to Switzerland in the official Mexican statistics) (ref. 6). Of the 60,000-ton total, about 25,000 tons were Mexipak (Siete Cerros), 20,000 tons Inia, and 15,000 tons Jori (ref. 7). In addition, 10,000 tons of Inia were imported from Algeria (ref. 7). In total, this is the largest seed import recorded in this publication.
[4] Includes Mexipak, Jori 69c (irrigated area), and Inia 66 (rainfed areas).
[5] This is an enormous increase in HYV area over 1970/71—almost too large to believe. Yet is is possible considering the massive quantity of seed imported and assuming a seeding rate of about 75 kg./ha.
[6] There was a sharp drop in overall wheat area from 1971/72 to 1972/73.
[7] Principally Mexipak, followed by Inia and Jori.

References

(1) Abdul Hafiz, "Report on Cereal Improvement and Production in Iraq," FAO, Cairo, April 1971, p. 7.
(2) Foreign Agricultural Service Aircomm from Rawalpindi to Program Compliance Division, Export Marketing Service, November 20, 1969.
(3) Letters from Abdul Hafiz, Project Manager, Regional Project, Field Food Crops, FAO, Cairo, December 6, 1973 and January 28, 1974.
(4) Abdul Hafiz, "Impact, Problems, and Potential of the Green Revolution," *Cereal Improvement and Production,* Information Bulletin, Near East Project, FAO, Jan./Apr., and May/Aug., 1973, p. 19.
(5) Data provided by N. Erus, Chief, Basic Data Unit, Statistics Division, FAO, Rome, January 19, 1976.
(6) Letter from John D. Jacobs, Assistant Agricultural Attaché, American Embassy, Mexico City, February 12, 1974.
(7) Letter from Hafiz, *op. cit.*, March 25, 1974.

Table 15—Lebanon: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1967/68	–	50	120 (1)
1968/69	–	400	1,000[1] (2)
1969/70	–	2,500	6,200[1] (2)
1970/71	–	7,000	17,300 (2)
1971/72	–	12,000	29,700 (2)
1972/73	–	20,000	49,400 (2)
1973/74	–	NA	NA
1974/75	–	NA	NA

[1] Mexipak.

References

(1) Abdul Hafiz, "Impact, Problems and Potential of the Green Revolution," *Information Bulletin,* Cereal Improvement and Production, Near East Project, FAO, Jan./April and May/Aug., 1973, p. 19.
(2) Estimate provided by Dr. Kingma of the Arid Lands Regional Agricultural Program, Ford Foundation, Beirut; forwarded in letter from Shackford Pitcher, Agricultural Attaché, American Embassy, Beirut, November 21, 1973.

Table 16—Morocco: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1967/68	1[1] (1)	200	500
1968/69	500[2] (3) (4)	4,900	12,100[3] (5)
1969/70	–	46,500	114,900[4,5] (5)
1970/71	–	90,000	222,400[4,5] (5)
1971/72	–	206,000	509,000[4,5] (5)
1972/73	–	294,000	726,500[4,5] (5)
1973/74	–	375,100	926,900[6] (6)
1974/75	–	300,000	741,300[6,7] (6)

[1] Siete Cerros (plus 150 kg. of Super X).
[2] Included 250 M.T. of Siete Cerros, 100 of Inia 66, 100 of Tobari 66, 25 of Penjamo 62, and 25 of Norteno.
[3] 50 percent, Siete Cerros; rest, Inia 66, Tobari 66, and Pnejamo 62 (ref. 6).
[4] Unofficial estimate made by U.S. Agricultural Attaché based on quantities of certified seed available, discussions with USAID agriculturists, and other information.
[5] The estimated breakdown by variety was as follows:

	908 (Italian)	*Siete Cerros*	*Tobari*	*Other*	*Total*
			Percent		
1969/70	44	32	25	0	100
1970/71	95	3	2	0	100
1971/72	91	7	–	2	100
1972/73	95	5	0	0	100

[6] Area planted by the Direction de la Recherche Agronomique (DRA) only. Data not available on the HYV area planted by individual farmers and agricultural cooperatives.
[7] Estimated. The varietal breakdown of the production of certified seed (in percent) was: Nesma, 40; 908, 33; Siete Cerros, 20; 2306, 7. The decline in area was related to dry weather.

References

(1) Department of State Airgram A-272 from Rabat, December 26, 1967.
(2) *CIMMYT Report, 1967-68,* p. 73.
(3) *Morocco: Wheat,* Spring Review (AID), March 13, 1969, pp. 2, 4.
(4) "Moroccan Agriculture Thrives on High-Yield Mexican Wheat," *Front Lines* (AID), February 15, 1969, p. 3.
(5) Foreign Agricultural Service Telegrams TOFAS 10 and TOFAS 13 from Rabat, March 22 and 27, 1974.
(6) Data provided by Mohamed Turkmany, Director, Seed Control and Multiplication Division, Direction de la Recherche Agronomique, Rabat. (Data gathered by the Office of the Agricultural Attaché, American Embassy and forwarded by Arthur Dommen, Visiting Agricultural Economist, USAID, October, 2, 1975.)
(7) *CIMMYT Report, 1968-69,* pp. 57, 97.

Table 17—Saudi Arabia: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1969/70	2[1] (1) (2)	—	—
1970/71	0.8[2] (2)	—	—
1971/72	—	—	—
1972/73	—	140	350[3,4] (3)
1973/74	—	2,000	5,000[3] (2)
1974/75	680[3,5] (4)	10,000	24,700[3] (4) (5)
1975/76	—		[6]

[1] Gift from West Pakistan; principally Mexipak 65 (known locally as White Mexipak).
[2] Super X; provided by the Ford Foundation in 1970.
[3] Super X (Mexipak).
[4] Planted on seed multiplication and demonstration farms. A national wheat improvement program was begun in 1971 utilizing the Super X seed provided by the Ford Foundation in 1970.
[5] Imported from Egypt. Of this amount, 500 M.T. were distributed for the 1974/75 crop and the remaining 180 M.T. were used for the 1975/76 crop.
[6] Two additional varieties were released: Jori 69, a durum variety; and Arz, a bread wheat (ref. 4).

References

(1) Foreign Agricultural Service Aircomm from Rawalpindi to Program Compliance Division, Export Marketing Service, November 20, 1969.
(2) Letters from Keith E. Henderson, Development Assistance Corporation, Riyadh, November 15, 1975, December 6, 1975.
(3) M. El-Saadi, "Saudi Arabia," *Proceedings of the Fourth FAO/Rockefeller Foundation Wheat Seminar* (Tehran, May/June 1973), FAO, Rome, 1974 (AGP:FC/21), p. 101.
(4) Keith Henderson, "Status of High Yielding Wheat Varieties in Saudi Arabia," Development Assistance Corporation, Riyadh, September 1975.
(5) *Wheat Production in Saudi Arabia,* Ministry of Agriculture and Water, Riyadh, January 1975, pp. 6–8.

Table 18—Syria: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1970/71	5,160[1] (1)	38,000	94,000[3] (3)
1971/72	–	75,000	185,300[3] (4)
1972/73	50[2] (2)	121,000	299,000[3,4] (2)
1973/74	–	224,000	553,500[3] (2)
1974/75	–	269,000	664,700[3] (2)

[1] The varietal composition was as follows: Siete Cerros, 1,870 M.T.; Inia, 1,150; Pitic 62,770; Lerma Rojo, 740; Mexipak 65, 540; and Penjamo 62, 90. Origin not indicated.
[2] Jori S-69.
[3] The distribution of HYV area between irrigated and rainfed land was as follows:

	Irrigated	*Rainfed*	*Total*
		Percent	
1970/71	66	34	100
1971/72	33	67	100
1972/73	44	56	100
1973/74	42	58	100
1974/75	44	56	100

[4] Mainly Pitic 62 and Siete Cerros.

References

(1) Abdul Hafiz, "Report on Cereal Improvement and Production in Syria," FAO, Cairo, July 1971, p. 6.
(2) Foreign Agricultural Service Telegram TOFAS 34 from Damascus, April 6, 1976. (Data provided by the Syrian Ministry of Agriculture and Agrarian Reform.)
(3) Adbul Hafiz, "Present Status of Wheat Research and Production Programmes in the Near East Region," FAO, Cairo, September 1971, Table III.
(4) Estimate provided by Dr. Kingma of the Arid Lands Regional Agricultural Program, Ford Foundation, Beirut; forwarded in Foreign Agricultural Service Telegram TOFAS 22, April, 23, 1974.

Table 19—Tunisia: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested		
	Metric tons	*Hectares*	*Acres*	
1967/68	50 (1)	800	2,000	(2)
1968/69	—	12,000	29,700	(3)
1969/70	—	53,000	131,000	(3)
1970/71	—	102,000	252,000	(3)
1971/72	—	60,000	148,300[1]	(3)
1972/73	—	99,000	244,600[2]	(3)
1973/74	—	55,000	135,900[2]	(4)
1974/75	—	54,900	135,700[2,3]	(5)

[1] The decrease may have been due to dissatisfaction of farmers with the quality of seed distributed during the 1970/71 season (ref. 6).

[2] In addition, the following areas were sown with locally selected and improved durum varieties:

	Hectares	*Acres*	*Reference*
1972/73	50,200	124,000	(6)
1973/74	100,000	247,100	(4)
1974/75	170,800	422,100	(5)

The most important durum variety is INRAT 69, a semi-dwarf developed in Tunisia from a cross of two local varieties (Kyperounda x Mahmoudi) (ref. 5). Newer varieties in the testing stage carry the Norin 10 dwarfing gene (ref. 7).

[3] A new Tunisian bread wheat variety Soltane, developed from a cross between Sonora 64 and Klein Rendidor, shows improved disease resistance, and is expected to become widely planted. Even more promising varieties are now in the testing stage (ref. 5).

References

(1) "Tunisia to Close Wheat Gap," *Front Lines* (AID), December 15, 1968, p. 7.
(2) Foreign Agricultural Service Report TN-9004 from Rabat, June 26, 1969.
(3) Letter from Gaylord L. Walker, Senior Agriculture Sector Advisor, USAID, Tunis, October 19, 1973 (data provided by the Office of Cereals).
(4) Foreign Agricultural Service Report TN-4004 from Rabat, December 17, 1974 (data provided by the Ministry of Agriculture Planning Office).
(5) Letter from Carl E. Ferguson, Agricultural Development Officer, USAID, Tunis, November 25, 1975 (preliminary estimates by the Office of Cereals).
(6) Letter from Buford H. Grigsby, Project Officer, Agricultural Production and Research, USAID, Tunis, November 8, 1973.
(7) Letter from George Varughese, CIMMYT, c/o Ford Foundation, Tunis, February 8, 1974.

Table 20—Turkey: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1966/67	60[1] (1)	600	1,500 (1)
1967/68	22,100[2] (2)	170,000	420,000 (2)
1968/69	–	579,000	1,430,700[3,4] (3)
1969/70	–	623,000	1,539,400[3,4] (3)
1970/71	–	640,000	1,581,400[3,4,5] (3)
1971/72	–	650,000	1,606,200[3,6] (3)
1972/73	–	NA	NA[7]
1973/74	–	NA	NA
1974/75	–	NA	NA[8]

[1] Sonora 64.

[2] Only 17,000 M.T. planted in fall; remainder planted in spring 1968. Included: 6,190 M.T. of Lerma Rojo 64; 6,950 of Penjamo 62; and 5,860 of Super X.

[3] Estimates of the area planted to Mexican HYV's by another source (ref. 4) differ somewhat:

	Hectares	*Acres*
1968/69	650,000	1,606,200
1969/70	650,000	1,606,200
1970/71	509,000	1,257,700
1971/72	623,000	1,539,400

[4] In addition, the following areas were planted to two other improved varieties, principally Bezostaya and some Wanser, in the winter wheat areas (ref. 5) (also see ref. 4):

	Hectares	*Acres*
1968/69	7,280	18,000
1969/70	69,200	171,000
1970/71	287,700	710,000

100 M.T. of Bezostaya, a Russian variety, were imported in the fall of 1967. Wanser is an American variety which was first imported in 1967.

[5] The HYV's in the spring wheat area were composed of both Mexican and Italian types. The varietal composition of the Mexican varieties was: Penjamo 89 percent, Lerma Rojo 9 percent, Super X 1 percent, and Pitic 1 percent (ref. 6).

[6] A comprehensive survey of 1,250 wheat farms in six regions of Turkey in the spring of 1973 (sponsored by CIMMYT) provided data on the proportion of area planted to HYV's. When this is combined with overall area estimates, the results are as follows for 1971/72 (ref. 7):

Region	*Area in wheat* 1,000 ha.	*Proportion of area in HYV's* Percent	*Area under HYV's* 1,000 ha.
Coastal area (spring)			
Mediterranean	814	97[a]	789
Aegean	399	35	140
South Mamara	365	40	145
Subtotal	1,578	68	1,047

[a] Figure may be high for two of the six provinces included.

Region	*Area in wheat* 1,000 ha.	*Proportion of area in HYV's* Percent	*Area under HYV's* 1,000 ha.
European area (winter)			
Thrace	407	79	320
Anatolia Plateau (winter)			
Central	4,723	7	316
Southeast	1,106	20	223
Subtotal	5,829	9	539
Total	7,814	25	1,933

On the basis of this survey, the HYV varietal composition in 1971/72 was:

Region	*Mexican*	*Italian* 1,000 ha.	*Bezostaya*
Coastal area (spring)			
Mediterranean	776.6	12.2	–
Aegean	130.5	–	–
South Mamara	31.4	37.6	75.6
Subtotal	938.5	49.8	85.2
European area (winter)			
Thrace	–	–	320.3
Anatolia Plateau (winter)			
Central	52.0	–	264.5
Southeast	99.5	35.4	88.5
Subtotal	151.5	35.4	353.0
Total	1,090.0	85.2	758.5

On this basis, the area planted to Mexican and Italian varieties was considerably higher than reported in the main table and in footnote 3.

[7] One source indicated that improved wheats occupied about 60 percent of the total spring wheat area; in turn, Penjamo 62 was grown on more than 90 percent of this area (ref. 8).

[8] In the spring wheat area, Penjamo 62 was still the predominant variety, but the Italian varieties were becoming more important, especially in South Mamara. In the winter wheat areas, Thrace was almost entirely planted to Bezostaya, while Bezostaya and Bolal (a new variety) were spreading in Central Anatolia and Cocorit 71 was making headway in the Southeast Anatolia. The Mexican wheat area is thought to have increased in 1974/75 due to decreased competition from cotton. (Ref. 7.).

References

(1) *1966-67 CIMMYT Report,* p. 69; *CIMMYT Report, 1967-68,* p. 59; Joseph R. Williams, "Wheat Program Leads Off Turkey's New 5-Year Plan," *Foreign Agriculture,* November 20, 1967, p. 5.

(2) *Wheat in Turkey,* Spring Reveiw (Airgram TOAID A-141 from Ankara, March 21, 1969), pp. 5-6, 12-13. (Also see L. M. Humphrey, *Mexican Wheat Comes to Turkey,* USAID, Ankara, April 1969.)

(3) Letter from William L. Davis, Agricultural Attaché, American Embassy, Ankara, November 16, 1973.

(4) Oddvar Aresvik, *The Agricultural Development of Turkey,* Praeger, 1975, pp. 168, 179-180. (Based on estimates provided by the Wheat Research and Training Project.)

(5) Abdul Hafiz: "Report on Cereal Improvement and Production in Turkey," FAO, Cairo, July 1971, p. 10; "Present Status of Wheat Research and Production Programmes in the Near East Region," FAO, Cairo, September 1971, Table III.
(6) Letter and enclosure from Keith M. Byergo, Deputy Food and Agriculture Officer, USAID, Ankara, October 12, 1971.
(7) Letters from Bill C. Wright, Agricultural Project Leader, Wheat Research and Training Center, Ankara, November 7, 1975, February 23, 1976.
(8) "Wheat Research and Production in Turkey, 1972–73," Wheat Research and Training Center (The Rockefeller Foundation) Ankara, pp. 1–3. (Draft of annual summary for CIMMYT provided by Bill C. Wright, Agricultural Project Leader, January 23, 1974.)

Wheat is fairly important in the more temperate nations of Africa (aside from the Mediterranean countries which are included with the Near East). The HYV's have found a modest foothold in several of these countries. Coverage in this section will basically be limited to five: Ethiopia, Kenya, Nigeria, the Sudan, and Tanzania. Both improved and high-yielding varieties are discussed.

In addition, the HYV's are being grown in several other African nations including Rhodesia and Senegal. CIMMYT has estimated that in Rhodesia about 22,000 ha. (54,400 acres) were planted to two HYV's in 1973 (Zambesi and Tokwe).[1] In Senegal, HYV's were planted for the first time in 1973/74, on an experimental basis.[2] Small areas are also reported to Chad, West Cameroon, Mali, and Ghana.[3]

South Africa is excluded because it is generally considered an economically developed nation. During the 1974/75 season, however, over 27 percent of the area was planted to Mexican varieties.[4]

Ethiopia

Ethiopia began to utilize improved wheat varieties on a commercial level in 1968. The area of improved and semi-dwarf varieties reportedly expanded as follows (in hectares): 1968, 950; 1969, 4,500; 1970, 15,000; 1971, 40,000; and 1972, 45,000.[5] The use of improved and semi-dwarf varieties rose from 14 percent of the total wheat area in 1969 to about 75 percent in 1973.[6] It is not known what proportion of this area was devoted to the semi-dwarf varieties of Mexican or Italian descent. Nor have more recent data been obtained.

Ethiopia did import some wheat seed from India: 0.87 M.T. in 1969/70 and 11.0 M.T. in 1970/71 (variety not stated).[7] As of 1973, the predominant wheat varieties included Laketch (a white grained Siete Cerros or line 8156 derivative), Supremo-Kenya x Yaqui 48, and Kenya Kanga (see table 1 for parentage). A large number of new varieties are under development; those under advanced multiplication in 1973 included: Inia 66, K4500, Kenya Mamba, and K4135.[8]

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[1] *CIMMYT Review, 1975*, p. 96. It has not been possible to obtain any further information from Rhodesia.

[2] Letter from Victor Lateef, Regional Agriculture Officer, USAID/ADO, Dakar, September 25, 1975.

[3] Letter from R. Glenn Anderson, CIMMYT, September 19, 1975.

[4] Letter from Aubrey D. Venter, Counsellor (Agricultural-Technical), Embassy of South Africa, Washington, D.C., October 28, 1975. For a listing of varieties, see the *CIMMYT Review, 1975*, p. 96.

[5] Alemayehu Wodageneh, "Ethiopia," *Proceedings of the Fourth FAO/Rockefeller Foundation Wheat Seminar* (Tehran, May/June 1973), FAO, Rome, 1974, p. 65.

[6] *CIMMYT Report on Wheat Improvement, 1973*, p. 71.

[7] Data provided by Robert C. Tetro, Jr., Assistant Agricultural Attaché, American Embassy, New Delhi, November 28, 1975.

[8] See *CIMMYT Report. . . , op. cit.*

Kenya

Wheat improvement has an unusually long history in Kenya. In 1910, a prominent wheat grower, Lord Delamere, employed an English plant breeder, G. W. Evans, to develop varieties resistant to stem rust. Evans initially employed varieties from Italy (Rieti), Australia, Canada (Red Fife), and Egypt. In 1920, a full-time plant breeder, G. I. L. Burton, was employed by the government. Originally Burton was stationed near Nairobi, but in 1928 the main station was set up at Njoro.[9] Some of the varieties developed by Burton at Njoro, such as Kenya, Kenya Blanco, and Kenya Rojo, were used in the early Mexican work. Unfortunately the parentage of most of these varieties is unknown; Burton's records were lost in a fire.[10]

Over time, Mexican varieties were in turn used in the Kenyan breeding program. In 1975, CIMMYT listed seven varieties of at least partial Mexican semi-dwarf extraction: African Mayo (1960), Kenya Lepard (1966), Kenya Kanga (1971), Trophy 68 (1969), Token (1969), Kenya Kiboko (1973), and Kenya Nyati (1973) (see table 1 for parentage).[11] Of the total wheat area in Kenya in 1974, about 46.7 percent or 49,100 ha. (121,300 acres) were planted to these seven varieties. The largest areas were planted to Kenya Lepard (15,800 ha.) and Africa Mayo (11,700 ha.). Similar data are not available for previous years.[12] These and the earlier varieties are also grown elsewhere in Africa.

Nigeria

Commercial bread wheat production in Nigeria began with development of four irrigation schemes in the northernmost part of the country in 1959. The area under wheat increased from a few hundred acres in 1959/60 to about 2,000 ha. (5,000 acres) in 1967/68. In 1960, over 300 varieties were introduced for selection purposes.[13]

Trials of Mexican semi-dwarf varieties began in 1966/67. By 1974/75 the HYV wheat area had expanded to 3,200 to 4,900 ha. (8,000 to 12,000 acres).[14] The area was divided between Kano State and the area around Lake Chad. Wheat is raised during the dry season under irrigation.

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[9] Foreign Agricultural Service Report No. 46 from Nairobi, October 16, 1959. Similar information, with slightly different dates, is provided in *Growing Wheat in Kenya*, Plant Breeding Station, Njoro (?), 1974, p. 1 (the date of Evans' employment is placed in 1906 and the establishment of the station at Njoro at 1927).

[10] E. C. Stakman, et al., *Campaigns Against Hunger*, Belknap/Harvard University Press, Cambridge, 1967, pp. 84–85; Lennard Bickel, *Facing Starvation: Norman Borlaug and the Fight Against Hunger*, Readers Digest Press, 1974, p. 132. Kentana resulted from a Kenya x Mentana cross.

[11] *CIMMYT Review, 1975*, pp. 95–96.

[12] "Third Field Estimate of 1974 Planted Kenya Wheat Crop," Kenya Wheat Board, February 21, 1975 (provided by James K. Freckmann, Agricultural Attaché, October 15, 1975). The varietal estimates were begun in 1974.

[13] D. J. Andrews, "Wheat Cultivation and Research in Nigeria," *Nigerian Agricultural Journal*, Vol. 5, No. 2, pp. 67–72.

[14] The former estimate was provided for 1975 in Foreign Agricultural Service Report No. NA-6093 from Lagos, February 6, 1975, p. 5; the latter estimate was

The principal early HYV's were Indus 66 and Siete Cerros. Sonora 63 was released in 1971 and Inia 66 is likely to be recommended in the future. With good management, yields of 4 M.T. per hectare are considered commercially feasible. Wheat is expected to have a prominent place in the cropping system. USAID has sponsored the assignment of a wheat production specialist and the training of a number of Nigerians at CIMMYT.[15]

Sudan[16]

Improved wheat, principally from Egypt (such as Giza 155), has been used extensively in the irrigated wheat area in the Sudan for a number of years. In 1971, a semi-dwarf variety known as Mexicani was released. It is a selection from a Mexican cross (table 1).[17] The estimated area planted to Mexicani has increased significantly:

Crop year	HYV area	
	Hectares	*Acres*
1972/73[18]	2,400	6,000
1973/74	20,000	49,400
1974/75	50,000	123,600
1975/76	126,000	311,300

As of 1975/76, the Mexicani area represented about 36 percent of the total wheat area; the rest was planted to Giza 155. Mexicani has a number of advantages over Giza 155—such as earlier maturity, stronger stem, and a 20 percent yield advantage—but it also has a yellow grain which is less attractive to farmers. Still, its area is expected to expand.

Tanzania

Mexican wheat varieties have been under study and in use in Tanzania for several years. Canada has been assisting wheat development at the Lyamungu Institute since 1970. In 1973, the Lyamungu Research Station made 270 M.T. of seed with Mexican parentage available, of which 180

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provided by 1974/75 in a letter from R. Reddin, Agricultural Research Institute, Ahmadu Bello University, to G. Anderson, CIMMYT, December 24, 1975 (forwarded by Winton Fuglie, USAID, Lagos).

[15] Reddin, *op. cit.*; Winton L. Fuglie, "Wheat in Nigeria," USAID, Lagos, January 30, 1976, 10 pp.

[16] Based, except as noted, on a letter from Dr. M. A. Khalifa, Plant Breeding Section, Agricultural Research Corporation, Wad Medani, Sudan, January 12, 1976.

[17] Selections from the same cross have been released as Moghan 1 in Iran, Anza in California, and WW15 in Australia (C. O. Qualset, et al., "Anza, New High-Yielding, Short-Statured Wheat Variety," *California Agriculture,* February 1973, pp. 14–15).

[18] M. A. Khalifa, "Sudan," *Proceedings of the Fourth FAO/Rockefeller Foundation Wheat Seminar* (Tehran, May/June 1973), FAO, Rome, 1974, p. 106.

M.T. were W-3503 and 90 M.T. were W-3654.[19] Most of the varieties developed at the Njoro Station in Kenya are reselected at Lyamungu. As of 1975, it has been estimated that all the varieties used in Tanzania carry Mexican germ plasm. It is not clear, however, what proportion of the area is planted to semi-dwarf varieties. Such data may become available in the future when the new Tanzania Seed Company becomes operative.[20]

[19] Letter from Henry C. Wiggin, USAID, Dar es Salaam, November 15, 1973.

[20] Letter from W. E. P. Davis, Agronomist, Agronomic Research Project (Ministry of Agriculture), Lyamungu, Moshi, October 21, 1975.

Although the HYV's discussed in this report were developed in Mexico, their principal use—aside from Mexico itself—has been in Asia and the Near East. This has been because the varieties most nearly achieve their yield potential under assured water supplies and with the application of fertilizer. Wheat is seldom raised under these conditions in Latin America outside of Mexico.

Not all of the Mexican varieties have been of dwarf stature. Research programs, utilizing the pre-dwarf varieties, were initiated in several Latin American countries by the Rockefeller Foundation in the 1950's.[1] A number of improved varieties of traditional height were developed, many of which are of significant economic importance.

The introduction of the semi-dwarf varieties in these national breeding programs is of more recent vintage—stemming largely from the mid-1960's. Some semi-dwarf varieties have been introduced and many others are being studied.[2] While the general lack of irrigation and fertilization have not enhanced the use of these varieties, conditions are changing and the use of fertilizer is increasing.

Such information as we have on the development and use of both improved and semi-dwarf varieties in seven countries (Argentina, Brazil, Chile, Colombia, Ecuador, Guatemala, and Peru) is summarized in this section. In addition, a semi-dwarf variety known as Estanzuela Dolores is expected to be released in Uruguay in 1977.[3]

Conspicuous by its absence is detailed coverage of Mexico. The reasons for this are a bit peculiar. The area planted to *improved* varieties in Mexico went over 90 percent of the total wheat area in 1957. The *semi-dwarfs* were first introduced in 1961, and began to replace the improved varieties. Unfortunately no historical records of area planted by variety seem to be available since 1964.[4] Hence, paradoxically, we cannot document the rate of adoption of the semi-dwarf HYV's in the country where they originated. But CIMMYT has estimated that perhaps 609,000 ha. (1.5 million acres) were planted to eight varieties in 1973;[5] if other varieties are included the

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[1] Details on early programs are provided in E. C. Stakman et al., *Campaigns Against Hunger,* Belknap/Harvard University Press, Cambridge, 1967, pp. 216–234. This book will be cited at several points in this section.

[2] Details are provided in the annual reports of CIMMYT from 1966/67 to the present.

[3] Letter from Antonio M. Saravia, Director General, Centro de Investigaciones Agricolas, Montevideo, to Mauro Fratocchi, Rural Development Office, USAID, Montevideo, January 15, 1976. The variety was developed in Argentina and has the parentage (Son 64 x SKE-LR64A).

[4] Estimates for 5 groups of varieties were compiled through 1964 by Nicolas Ardito Barletta, "Costs and Social Benefits of Agricultural Research in Mexico," University of Chicago, Department of Economics, Ph.D. dissertation 1970, pp. 136, 140. Data for the semi-dwarf group were reported for 1963 and 1964 only.

[5] *CIMMYT Review, 1975,* p. 97. The varietal breakdown was:

	Percent
Lerma Rojo 64 and Delicias	10.3
Siete Cerros 66	12.2
Yecora 70, Cajeme 71, Tanori 71	73.9
Jori 69, Corocit 71 (durum)	3.6

figure may be even higher. It is generally assumed that 90 to 95 percent or more of the total Mexican wheat area is devoted to the HYV's.

Based on developments to date, it would appear that the area planted to HYV's could increase substantially in several Latin nations, particularly Argentina and Brazil, in the future.

Argentina

Improved varieties of wheat have reportedly been available to Argentine farmers since 1935. As of the mid to late 1960's, almost the entire wheat area was planted with *improved* varieties.[6]

In 1963, CIMMYT's predecessor organization (the Office of Special Studies), began a program of informal cooperation with the Coordinated National Wheat Breeding Program of the Instituto Nacional de Technologia Agropecuaria (INTA). In 1972, the first two *semi-dwarf* varieties (re-selections) were named and approved for release: Marcos Juarez and Precoz Paraná.[7] INTA has subsequently released other new varieties including Balcarceno, Diamante, Calden, Insurgentes, and Leones.

Three semi-dwarf varieties were also developed by Dekalb Argentina S.A.: Lapacho (released in 1973), Tala (1973), and Urunday (1975). Their parentage is:

- Lapacho and Urunday. Pitic-Chris sib x Sonora 64;
- Tala. Sonora 64-Klein Rendidor x Massau x No. 5.

The parentage of Lapacho and Urunday is the same as Ciano 67, but the selections have more resistance to stem rust races in Argentina. Tala is slightly taller than Lapacho and Urunday and does not resemble other Mexican varieties as closely.[8]

Just how large an area is planted to the semi-dwarf varieties is most uncertain. CIMMYT has placed the 1973 area at about 50,000 ha. (123,600 acres).[9] Most of the farmers, however, save their own seed and no official estimate of the area planted to noncertified ("non fiscalizado") seed is available. Estimates received for the 1975/76 season vary widely:

- A CIMMYT official, following a trip to Argentina in late 1975, reported that research officials estimated that 16 to 18 percent of the total area (or 0.9 to 1.0 million ha.) was planted to Lapacho, Urunday, and Marcos Juarez.[10]
- A subsequent estimate by a high Argentine agricultural official placed the HYV area at about 30 percent of the total.[11]
- Two wheat breeders report estimates of 50 to 60 percent of the total

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[6] D. H. Fienup, R. H. Brannon, and F. A. Fender, *The Agricultural Development of Argentina,* Praeger, 1969, p. 106.

[7] *CIMMYT Annual Report, 1972,* p. 84. Further details on the breeding work in Argentina are provided on pp. 84–86.

[8] Letter from Dr. Charles F. Krull, Dekalb Italiana, Centro Ricerche, 31040 Chiarano (TV), Italy, January 28, 1976. Dr. Krull was formerly in charge of wheat breeding for Dekalb in Argentina.

[9] *CIMMYT Review, 1975,* p. 98.

[10] Letter from R. Glenn Anderson, CIMMYT, December 30, 1975.

[11] Cited by Norman Borlaug, CIMMYT, in phone conversation, February 17, 1976.

area planted to the Dekalb varieties (with most in Lapacho and Tala). An additional area was planted to the INTA varieties.[12]

Obviously these estimates produce widely varying estimates of total HYV area and it has not been possible to reconcile them. In any case, it would appear that considering the vast wheat area in Argentina (5.1 million ha. or 12.6 million acres in 1975), a massive area is being planted to semi-dwarfs.

Considering the very limited use of fertilizer and irrigation for wheat in Argentina, this development is somewhat surprising. But the HYV's would be expected to give a greater response than improved varieties to the high natural fertility of the Pampas. Moreover, their shorter growing season has facilitated their use in double cropping rotations with soybeans. Additional HYV's are expected.[13]

As of early 1975, however, there were a few problems: (1) the HYV's have been classified as hard wheats and millers were evidently reluctant to pay a premium for them over semi-hard wheat; and (2) their diffusion in the northern zones coincided with weather conditions which led to generally low protein levels.[14]

Brazil[15]

Brazil has a long history of use of improved wheat. One of the earliest and best known varieties was Frontana; it was developed from a cross of Fronteria (Alfredo Chaves 6 x Polyssu) and Mentana (an Italian variety discussed in Chapter II) in 1930 and was released in 1940. It is still being grown in the western part of Rio Grande do Sul State and was used in breeding a number of the Mexican varieties. Frontana itself, however, is not a semi-dwarf.

A number of other current commercial varieties have Mexican wheats in their pedigree, but—with several exceptions to be noted below—none can be considered semi-dwarfs. This is also true of several improved varieties recently released or about to be released—such as the PAT 1 and PAT 10 lines from FECOTRIGO. Some of the varieties under experimentation, however, are semi-dwarf. In a few years, FECOTRIGO and other groups

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[12] Letters from: Krull, *op. cit.*; John W. Gibler, Technical Coordinator, Programa Acelerado de Melhoramento do Trigo, Porto Alegre, Brazil, November 4, December 4, 1975 (citing estimates from colleagues in Argentina).

[13] Borlaug, *op. cit.*; Krull, *op. cit.*, February 18, 1976.

[14] Letter from James Rudbeck, Agricultural Attaché, American Embassy, Buenos Aires, February 19, 1976; article in *Clarin Rural* (Buenos Aires), January 31, 1976, p. 6.

[15] This section is almost entirely based on information provided in letters from Dr. John W. Gibler, Research Coordinator, Federacao das Cooperativas Brasileiras de Trigo (FECOTRIGO), Porto Alegre, October 14, 1975; November 4, 1976. Helpful information was also received from: R. Glenn Anderson, CIMMYT, October 30, 1975; and Edmond Missiaen, Assistant Agricultural Attaché, American Embassy, Brasilia. Details on the Brazilian wheat breeding work are provided in the CIMMYT annual reports starting in 1969-70. For background, also see John C. McDonald, "An Assessment of Brazil's Efforts to Grow More Wheat," *Foreign Agriculture*, December 29, 1969, pp. 8, 9.

hope to have some Mexican-Brazilian crosses ready for release. And some Mexican selections are currently under study.

There are at least two exceptions to this pattern. An introduction from Paraguay, known as Paraguay 214 and thought to be a sister line of the Mexican semi-dwarf variety Jaral, accounted for about 20 percent of total wheat production in Paraná State in 1975 (the total wheat area was nearly 1.1 million ha.). It was also planted on nearly 2,000 ha. (5,000 acres) in Mato Grosso State. Also, Sonora 63/64 accounted for about 7.1 percent of total wheat production in Paraná in 1975.[16]

The biggest jump in semi-dwarf area will come in 1976 in the State of Paraná. A commission from that State purchased 14,000 M.T. of semi-dwarf Mexican wheat (9,000 M.T. of Tanori F71 and 1,000 M.T. of Jupateco F73 from Mexico, and 4,000 M.T. of Inia F66 from California) for planting in April 1976 and harvest in August and September.[17] At the same time, 4 M.T. of Mexican wheat seed (15 semi-dwarf Mexican varieties) were purchased for a 40-ha. pilot project in Bahia State (the São Francisco valley is considered to have particular promise).

For the present, the area likely to be planted to Mexican semi-dwarfs is limited to certain areas of Brazil because of susceptibility to aluminum toxicity in acid soils. A cooperative program was established with CIMMYT in 1972 to select more resistant varieties.

Chile

A wheat improvement program was initiated in Chile in 1955 in cooperation with the Rockefeller Foundation. Dr. Joseph A. Rupert, who had worked in Mexico, started testing lines from the two countries. Several were subsequently selected and released in 1958 (Orofen and Rulofen) and 1961 (including Orofen 50 and Chifen).[18]

Wheat research carried out by the Institute de Investigaciones Agropecuarias (INIA) led to the release of 21 varieties from 1964 to 1975. Of these, 11 semi-dwarfs are raised commercially. As of 1976/77 they will be raised on about 193,000 ha. (476,900 acres).[19]

The leading semi-dwarf varieties, their year of release, and approximate percentage of total HYV area (in 1976/77) were: Toquifen (1968), 31.1;

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[16] Statistics from "Visao Panoramica da Triticultura Paranaense na Safra de 1975," Paraná Agronomic Institute (IAPAR), Londrina, p. 2 (obtained by Robert Wicks, Agricultural Officer, U.S. Embassy, São Paulo; forwarded by Edmond Missiaen, Assistant Agricultural Attaché, Brasilia, February 27, 1976). Paraguay 214 accounted for 19.3 percent of wheat production in Paraná, 11.0 percent in 1973, and 1.5 percent in 1973. Sonora 63/64 represented 2.1 percent of production in 1974 and none in 1973.

[17] Mexican records indicate an export of 7,096 M.T. of wheat seed to Brazil in 1975 (letter from Richard Welton; Agricultural Attaché, American Embassy, Mexico City, March 10, 1976).

[18] Stakman, et al., *op cit.*, pp. 232, 233, 271.

[19] Letter from Ignacio Ramirez, Head, Wheat Project, Institute de Investigaciones Agropecuarias, Santiago, May 19, 1976. Area estimate based on seed sales (Telegram TOFAS 54 from Santiago, June 1, 1976).

Quilafen (durum, 1970), 31.1; Melifen (1974), 10.4; Aurifen (1973), 7.8; Mexifen (1973), 7.8; Antufen (1974), 5.2; Loncofen (1973), 2.6; Naofen (1974), 1.6; and other, 2.4.[20]

Colombia[21]

A wheat improvement program was begun in Colombia in 1926. Mexican varieties were introduced by Dr. Juan Orguela in 1949 and by Dr. Joseph A. Rupert of the Rockefeller Foundation in 1950. The first variety of Mexican ancestry released was Menkemen 52 (Mentana 48 x Kenya), a sister of Lerma 50. This was followed by Bonza 55 (Yaqui 48 x Kentana 48) in 1955 and Narino 59 in 1959. In addition to being higher yielding than native varieties, the new varieties were resistant to yellow rust.

Semi-dwarf varieties from Mexico were introduced in 1958. But the effort to incorporate the smaller plant type characteristic did not immediately gain force. Major varieties subsequently introduced through the cooperative efforts of the Rockefeller Foundation and the Instituto Colombiano Agropecuario (ICA), were:

- 1963: Tall (1.20 m.-1.25 m.): Bonza 63, Crespo 63.
  Normal (1.05 m.-1.10 m.): Miramar 63, Napo 63.
  Semi-dwarf (0.95 m.-1.05 m.): Tiba 63, Tota 63.
- 1964: Normal: Miramar 64.

ICA took over direction of the Wheat Improvement Program at the end of 1964. Three tall varieties were named in 1968: Samaca 68, Sugamuxi 68, and Zipa 68. Because of their resistance to yellow rust and other qualities, the Colombian varieties found a wide distribution in other nations.

The area planted to improved and semi-dwarf varieties, however, followed a peculiar pattern. It increased through 1968 to a peak area of about 54,600 ha. (134,900 acres), and then declined through 1973 to a low of 9,200 ha. (22,700 acres). The decline reflected a more general drop in overall wheat area; some observers believe that this drop was at least partly due to imports of U.S. wheat under the PL-480 program and unfavorable prices.[22]

As of 1975, it appears that little, if any, semi-dwarf wheat (as defined above) was raised in Colombia. ICA has a new semi-dwarf variety named PM-8 which is expected to be released shortly and reportedly yields more

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[20] *Ibid.*

[21] This section was initially based on: Stakman, et al., *op. cit.*, pp. 222, 223, 269-271; and Reed Hertford, Carlos Trujillo, et al., "Productivity of Agricultural Research in Colombia," in *Resource Allocation and Productivity in National and International Agricultural Research* (ed. by T. M. Arndt, D. G. Dalrymple and V. W. Ruttan), University of Minnesota Press, 1976, in press. A draft copy was, through the courtesy of Dr. Rafael Marino Navas, reviewed by ICA and a number of changes and additions were suggested (I am indebted to Norman Collins of the Ford Foundation for his help in this matter).

[22] Leonard Dudley and Roger Sandilands, "The Side Effects of Foreign Aid: The Case of Public Law 480 Wheat in Colombia," *Economic Development and Cultural Change,* January 1975, pp. 325-336.

than Bonza 63.[23] The use of such varieties may be restrained by the current limited use of irrigation and fertilization for wheat.

Ecuador

A wheat improvement program was established by the Ministry of Agriculture in 1956. The Rockefeller Foundation agreed to provide the advisory services of Dr. John Gibler, leader of the wheat work in Colombia. Thus, early use was made of Colombian and Mexican varieties.[24]

While the major improved varieties in current use have some Mexican ancestry, they are not semi-dwarfs.[25] The area planted to the *improved* varieties during the 1974/75 season totaled about 45,600 ha. (1,126,500 acres).[26] The varietal composition was (in percent): Crespo 63, 40; Amazonas, 33; Napo 63, 10; and other 17.[27] Other improved varieties include Atacazo, Cayambe 73, Romero 73, and Ruminahui.[28] Newer varieties in the testing stage carry the dwarfing characteristic.

Guatemala

The wheat area of Guatemala has long been planted to Mexican varieties.

The first introductions were made in 1949 and 1950 in the highlands where they evidently were well adapted. A book published in 1967 stated that "for more than a decade the entire acreage of wheat in Guatemala has been sown to Mexican-bred varieties." The Mexican varieties were also joined by the Colombian variety Narino (of Mexican extraction) which found widespread use in the 1960's.[29]

Guatemala has imported significant quantities of Mexican wheat seed in recent years: 506 M.T. in 1967, 22 in 1970, and 100 in 1971.[30] CIMMYT

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[23] Letter from Hector A. Sarmiento, USAID, American Embassy, Bogota, February 11, 1976.

[24] Stakman, et al, *op. cit.*, pp. 229, 270.

[25] Letter from R. Glenn Anderson, CIMMYT, December 9, 1975.

[26] Letter from C. Milton Anderson, Agricultural Attaché, American Embassy, Quito, December 1, 1975. (Data provided by USAID in cooperation with the National Agricultural Research Institute.)

[27] *Ibid.* Crespo, Amazonas, and Napo were "Colombian" varieties, of partial Mexican extraction, developed by Dr. Gibler. Crespo was released simultaneously in Ecuador and Colombia. Amazonas was crossed in Colombia but released in Ecuador. (Letters from: C. M. Anderson, *op. cit.*, December 30, 1975; John W. Gibler, Programa Acelerado de Melhoramento do Trigo, Porto Alegre, Brazil, March 15, 1976.)

[28] Letter from Dr. Enrique Ampuero P., Director General, Instituto Nacional de Investigaciones Agropecuarias, Estacion Santa Catalina, Quito, Ecuador, October 28, 1975.

[29] Stakman, et al., *op. cit.*, p. 268; letters from Eugenio Schiever, Antigua, Guatemala, September 16, 1975, October 10, 1975.

[30] Letter from Richard A. Smith, Agricultural Attaché, American Embassy, Mexico City, January 14, 1974.

has noted that the major varieties in 1973 included Narino 59, Pato, and Maya 74; it placed the total area of the three at about 30,000 ha. (74,000 acres).[31]

Peru

Peru made early use of Mexican and Colombian varieties. Sierra 1 and Sierra 2 were sister lines of the Mexican variety Yaktana 54. The Colombian varieties Bonza and Narino were also utilized.[32] The major varieties in current use, however, do not have Mexican ancestry and are not semi-dwarf.[33]

In 1974, the area planted to *improved* varieties totaled about 16,300 ha. (40,300 acres). The varietal breakdown was (in percent): Ollanta, 62.1; Cahuide, 16.2; Helvia Fron, 10.9; and Tinajones, 10.8.[34]

Many of the new varieties in the testing stage incorporate Mexican blood and CIMMYT expects to contribute more heavily to the varietal improvement program in the future.[35]

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[31] *CIMMYT Report, 1975,* p. 97.

[32] Stakman, et al., *op. cit.*, pp. 270, 271.

[33] Letter from R. Glenn Anderson, CIMMYT, December 9, 1975.

[34] Letter from Julio A. Castilla, Agricultural Economist, Office of Agricultural Attaché, American Embassy, Lima, Peru, November 3, 1975. (Data provided by the Ministry of Food; reporting for 1974 and 1975 was significantly improved over previous years.) The parentage of these varieties is: Ollanta and Cahuide, Narino 59 x Frontana-K58-Newthatch (FKN); Helvia Fron, Helvia x FKN (Anderson, *op. cit.*).

[35] Anderson, *op. cit.*

IV. HIGH-YIELDING RICE VARIETIES

This chapter summarizes data on area of high-yielding varieties of rice planted or harvested, and fragmentary information on seed imports, for developing nations in Asia (South and East), the Near East (West Asia, North Africa), Africa, and Latin America. Each of the continents is handled somewhat differently.

The Asian portion follows the format used in the previous chapter on wheat. A separate table is provided for each of 13 nations. Data which are particularly tentative or which are preliminary estimates for the 1975/76 season are placed in parentheses. Data are generally rounded to the nearest hundred; consequently, hectare and acre figures do not convert precisely. Available information on rice improvement in the People's Republic of China and North Vietnam is summarized in narrative form.

Only scattered preliminary observations are available for the Near East and Africa. These are summarized in short notes.

The Latin American section is a blend of the above two systems. Brief notes contain available statistics in tabular form.

Virtually all of the data on imports of Philippine seed cited in this chapter were provided by Dr. Randolph Barker of IRRI. Most of these statistics were supplied through correspondence in October 1970; the reference to this data in the country tables reads simply "Barker (October 1970)." In addition, reference is made to an article by Dr. Barker, "Economic Aspects of High-Yielding Varieties of Rice, With Special Reference to National Price Policies," in the *Monthly Bulletin of Agricultural Economics and Statistics,* June 1969, pp. 1–2; it is noted as "Barker (June 1969)."

The parentage of most of the varieties mentioned in this chapter is summarized in table 3 in Chapter II.

ASIA

Rice production is of immense importance in South and East Asia. It is in this region that the semi-dwarf HYV's have found their greatest application.

This section: (1) summarizes statistical data on seed imports and plantings in 13 nations (in the case of Laos no recent data are available); and (2) reviews the development of improved and high-yielding varieties of rice in the People's Republic of China and North Vietnam. The statistical tables are similar in format to those in the wheat chapter; the latter section is narrative in nature.

Several Asian countries have been excluded or omitted. Japan is a developed nation and therefore excluded. No data of any sort are available for Cambodia.[1] Taiwan was largely planted to improved varieties in the 1920's and 1930's and is omitted.[2]

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[1] A 1976 news account, however, states that "... there are reports of a second crop being planted—a rarity in most of Cambodia in the past—and promises that even a third crop will follow this year" (Lewis M. Simons, "A Traumatic Year for Indochina," *Washington Post,* April 25, 1976, p. C2). This suggests, but does not prove, the use of HYV's.

[2] A few notes on the varietal situation in Taiwan, however, are included here (also see Chapter II). Taichung Native 1, the first of the semi-dwarf indica varieties, was selected from a cross between Dee-geo-woo-gen and Tasi-yuan-chung made in 1949. It was officially released in 1960 and by 1965 accounted for about 10 percent of the total area; it then gradually decreased due to pest problems. Other semi-dwarf indicas, such as TN-2 and the Chianung-sen series, were also released. A ponlai variety, Tainan-5, was released in 1965 and by 1970 accounted for 39 percent of the area; it has subsequently gradually declined in area but is still the leading variety for both crop seasons. A recent report of the Joint Commission on Rural Reconstruction (JCRR) notes that Tainan-5 has several agronomic weaknesses, "such as a tall culm (over 100 cm.) which may cause a severe lodging under heavy fertilization." The JCRR is supporting a series of efforts "to develop a new genetic complement capable of overcoming these deficiences." (Letter from T. T. Chang, IRRI, February 23, 1976; *29th General Report of the Joint Commission on Rural Reconstruction,* January to June 1974, Taipei, p. 14.)

Table 21—Bangladesh: HYV Rice

Crop year	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1966/67	10	200	500 (2)
1967/68	1,500[1] (1)(2)	67,200	166,000 (6)
1968/69	–	154,200	381,000[7] (6)
1969/70	4.4	263,900	652,000[7] (7)
1970/71	1,800[2] (3)	460,100	1,137,000[7] (7)
1971/72	701[3] (4)	623,600	1,541,000[7] (7)
1972/73	7,000[4] (5)	1,064,400	2,630,000[7] (7)
1973/74	5,200[5] (5)	1,548,800	3,827,000[3] (8)
1974/75	–	1,443,600	3,567,000[7] (8)
1975/76	1,100[6] (4)		

[1] IR-8 planted during boro (winter-spring) season.
[2] IR-20 received from commercial sources in the Philippines.
[3] Imported from India; 470 M.T. of Jaya and 231 M.T. of IR-8.
[4] "In 1972, the Bangladesh Government imported about 7,000 M.T. of IR-20 seed from the Philippines, which is the largest consignment of rice seeds ever imported by any country" (ref. 5).
[5] IR-20 exported from the Philippines in 1973. (Details on the introduction and use of IR-20 are provided in ref. 9.)
[6] IR-20; imported from India (through September 1975).
[7] The approximate seasonal distribution of the IRRI varieties was:

	Aus (spring-summer)	*Aman (summer-fall)*	*Boro (winter-spring)*	*Total*
		Percent		
1968/69	4.3	1.3	94.4	100
1969/70	6.6	4.5	88.9	100
1970/71	7.0	17.6	75.4	100
1971/72	7.8	40.6	51.6	100
1972/73	6.2	52.4	41.4	100
1973/74	8.6	53.4	38.0	100
1974/75	19.6	34.7	45.7	100

References

(1) Letter from Leon F. Hesser, Assistant Director of Agricultural Policy, USAID, Rawalpindi, October 9, 1969.
(2) *Rice and Wheat in Pakistan,* Spring Review (AID), March 17, 1969, pp. 2–5.
(3) Barker (October 1970). Also see Foreign Agricultural Service Report PK-1032 from Islamabad, May 14, 1971.
(4) Data provided by Robert C. Tetro, Assistant Agricultural Attaché, American Embassy, New Delhi, November 28, 1975 (data in turn obtained from National Seeds Corporation).
(5) *IRRI Annual Report for 1972,* p. 1 (source of quote); data provided by Randolph Barker of IRRI, January 1974.
(6) "Country Field Submission: Pakistan, FY 1971," AID, August 1969, Appendix A, Table 1; letter from Carl O. Winberg, Agricultural Attaché, American Embassy, Rawalpindi, October 7, 1969.
(7) *Bangladesh Agriculture in Statistics,* Ministry of Agriculture, Agro-Economic Research Section, Statistical Series No. 1, November 1973.

(8) Data provided by Shafial Alam, Office of Agricultural Attaché, American Embassy, New Delhi, December 1975.

(9) Foreign Agricultural Service Report PK-1035 from Islamabad, May 21, 1971 (enclosure by Refugio I. Rochin on "Farmer's Experiences with IR-20 Rice Variety and Complementary Production Inputs: East Pakistan, Aman-1970." May 1971, 35 pp., subsequently published in *The Bangladesh Economic Review,* January 1973, pp. 71–94). Buford H. Grigsby, "Introduction of IR-20 Rice Into East Pakistan," USAID, Dacca, January 14, 1972, 12 pp.

Table 22—Burma: HYV Rice

Crop year	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1966/67	0.1[1] (1)	8	19[6] (3)
1967/68	200 [2] (1)	3,400	8,500[6] (3)
1968/69	– [3]	166,900	412,400[7] (3)
1969/70	200 [4] (2)	143,000	353,300[8] (4)
1970/71	100 [5] (2)	190,900	471,800[9] (4)
1971/72	–	185,100	457,300[8] (4)
1972/73	–	199,200	492,200[8] (4)
1973/74	–	252,600	624,200[8] (5)
1974/75	–	332,200	820,900 (5)
1975/76	–	(370,300)	(915,000)[9] (5)

[1] IR-8 imported from IRRI in 1966.
[2] IR-8 imported from the Philippines in 1967.
[3] IR-8, IR-5; less than 0.1 M.T. of each imported from IRRI in 1968.
[4] IR-5 imported from the Philippines in 1969.
[5] IR-20 imported from the Philippines in 1970.
[6] IR-8.
[7] IR-8.
[8] The approximate varietal composition by season was as follows:

	Yagyaw 1[a] *(IR-8)*	*Yagyaw 2*[b] *(IR-5)*	*C4-63*[b]	*Ngwetow*[b]	*Total*
			Percent		
1969/70	90.3	3.3	–	6.4	100
1970/71	5.3	86.1	0.3	8.3	100
1971/72	2.6	76.9	13.1	7.4	100
1972/73	1.8	72.9	17.7	7.5	100
1973/74	–	70	22	8	100
1974/75	–	73	20	7	100
1975/76	–	80	17	3	100

[a] Sown area.
[b] Harvested area. Ngwetoe is an improved local variety.

IR-8 was not accepted by farmers or producers. C4-63 is considered well adapted to growing conditions in upper Burma and is expected to partly replace IR-5 there. IR-20 ("Shwewarhnan"), IR-22 ("Lonethweshwewar"), and IR-24 ("Shwewarying") were, as of August 1973, shortly to be released to farmers (ref. 6). An improved strain of IR-5 has been produced by irradiation and is to be distributed in lower Burma (ref. 7).
[9] Projection.

References

(1) Barker (June 1969). Also Gladys Charitz, "Rice Surplus Affirms Success," *Journal of Commerce,* March 29, 1968.
(2) Barker (October 1970).
(3) Official sources, August 4, 1970.
(4) *Report to the People, 1972–73,* Rangoon, 1973, part IV, chp. 1, par. 56; official sources, October 18, 1973.

(5) Planning and Statistical Office, Ministry of Agriculture and Forestry, Rangoon (forwarded by Leslie Scott, American Embassy, Rangoon, September 17, 1975).
(6) Moe Myint, "A Welcome by Emerald-Green Fields—3," *Working People's Daily*, Rangoon, August 10, 1973.
(7) "Agri Research Produces Better Quality Rice," *The Guardian*, Rangoon, October 12, 1973.

Table 23—India: HYV Rice

Crop year	Quantity of seed imported	Area planted or harvested		
	Metric tons	*Hectares*	*Acres*	
1964/65	—[1] (1)	90	200[8]	(4)
1965/66	6[2] (1)	7,100	17,650[9]	(1)
1966/67	80[3] (1)	888,400	2,195,200[10]	(5)
1967/68	20[4] (2)	1,785,000	4,410,700[10]	(5)
1968/69	—[5] (3)	2,681,000	6,624,800[10,11,12]	(5)
1969/70	—[6] (3)	4,253,600	10,510,500[12]	(5)
1970/71	—[7] (3)	5,454,000	13,476,700[12]	(5)
1971/72	—	7,199,400	17,789,800[12]	(5)
1972/73	—	8,107,400	20,033,400[12]	(6)
1973/74	—	9,718,200	24,013,700[12]	(6)
1974/75	—	11,045,200	27,292,700[12]	(6)
1975/76	—	(12,500,000)	(30,887,500)[13]	(6)

[1] Taichung Native-1, hereinafter noted as TN-1. Two kg. were taken to India in a suitcase by the manager of the National Seeds Corporation.

[2] TN-1. One M.T. was shipped by air freight from IRRI in June 1965. Another 5 M.T. were received by ship from Taiwan in October 1965.

[3] TN-1. Gift of Joint Commission for Agricultural Reconstruction in Taiwan.

[4] IR-8 (from IRRI). Ten M.T. were provided by the Ford Foundation and arrived in mid-December 1966. The other 10 M.T. were provided by the Rockefeller Foundation and arrived in Calcutta in February 1967.

[5] Less than 0.1 M.T. of IR-5 from IRRI in 1968.

[6] Import of less than 0.1 M.T. each of IR 5-81 and IR 5-114 from IRRI in 1969. (Neither is an official variety, but rather a selection.)

[7] Import of less than 0.1 M.T. each of IR-20 and IR-22 from IRRI in 1970.

[8] ADT-27.

[9] Composed of ADT-27 (14.2 percent) and TN-1 (85.8 percent). Of the ADT-27 area, virtually all was in the rabi (winter) season.

[10] The approximate seasonal distribution was:

	Rabi (winter)	*Kharif (summer)*	*Total*
		Percent	
1966/67	43	57	100
1967/68	38	62	100
1968/69	29	71	100

[11] Within the rabi season, IR-8 accounted for about 49 percent of the area harvested, TN-1 22 percent, and ADT-27 and others 28 percent (ref. 7).

[12] The distribution of this area by state was:

	Tamil Nadu	*Andhra Pradesh*	*West Bengal*	*Uttar Pradesh*	*Others*	*Total*
1966/67	17.2	31.0	3.0	7.8	41.1	100
1967/68	24.8	19.0	7.9	8.4	39.9	100
1968/69	23.8	7.6	9.9	12.3	46.2	100
1969/70	26.8	12.3	10.8	13.2	36.9	100
1970/71	33.4	9.9	9.7	12.4	34.6	100
1971/72	31.2	10.1	9.8	13.8	35.1	100
1972/73*	27.5	14.7	8.4	11.3	38.1	100
1973/74*	23.6	13.2	8.7	10.8	43.7	100
1974/75*	18.2	17.7	8.5	13.3	42.3	100

*Preliminary.

[13] Most popular varieties include IR-8, Jaya, IR-20, Ratna, Pusa-2-21, and Mashuri.
[14] Target.

References

(1) Carroll P. Streeter, *A Partnership to Improve Food Production in India,* The Rockefeller Foundation (undated: 1969 or 1970), pp. 26–29.
(2) *Ibid.*; letter from Streeter, April 14, 1970; letter from Randolph Barker, IRRI, March 31, 1970.
(3) Barker (October 1970).
(4) "Rice Crop Proves Tanjore Program's Worth," *Foreign Agriculture,* March 4, 1968, p. 7; Department of State Airgram A-44 from Madras, October 14, 1967.
(5) Foreign Agricultureal Service Report IN-5027 from New Delhi, May 14, 1975.
(6) Data provided by Ivan E. Johnson, Agricultural Attaché, American Embassy, New Delhi, January 2, 1976.
(7) "Evaluation Study of High-Yielding Varieties Programme, Report for the Rabi 1968-60—Wheat, Paddy, and Jowar," Planning Commisssion, New Delhi, November 1969, p. 50.

Table 24—Indonesia: HYV Rice

Crop year	Quantity of seed imported	Area planted or harvested[7,8]	
	Metric tons	*Hectares*	*Acres*
1966/67	0.2[1] (1)	–	–
1967/68	–	–	–
1968/69	1 [2] (2)	198,000	489,900 (6)
1969/70	–	831,000	2,054,000 (5)
1970/71	– [3] (3)	902,600	2,230,400 (5)
1971/72	–	1,332,900	3,293,700 (5)
1972/73	1 [4] (4)	1,928,000	4,764,200 (5)
1973/74	1 [5] (5)	3,100,800	7,662,000 (5)
1974/75	2 [6] (5)	3,440,000	8,500,200[9] (7)
1975/76			[10]

[1] 200 kg. (440 lbs.); introduced from IRRI in 1966. "There have been additional imports of small lots of seed but they have probably not exceeded one metric ton" (ref. 1).

[2] C4-63; developed at the College of Agriculture at the University of the Philippines; imported in first 6 months of 1968.

[3] 100 kg. (220 lbs.) each of IR-20 and IR-22 were introduced in January 1969 and February 1970, respectively, with USAID assistance.

[4] One metric ton of IR-20 from IRRI.

[5] 1,000 kg. (0.5 M.T.) of IR-20 and 5 kg. of IR-26. Imported by the Central Research Institute for Agriculture and the Ministry of Agriculture.

[6] 1,020 kg. of IR-28; 1,020 kg. of IR-30; and 20 kg. of 2061. Imported by the Central Research Institute for Agriculture and the Ministry of Agriculture.

[7] Includes the following HYV's: IR-5, IR-8, IR-20, C4-63, Pelita I/1, and Pelita I/2.

[8] The seasonal distribution was as follows:

	Dry (Apr.-Sept.)	*Wet (Oct.-Mar.)*	*Total*
	Percent		
1968/69	9.1	90.9	100
1969/70	36.8	63.2	100
1970/71	27.3	72.7	100
1971/72	31.2	68.8	100
1972/73	26.8	73.2	100
1973/74	29.4	70.6	100
1974/75	34.7	65.3	100

[9] These figures are slightly lower than those reported by the Directorate of Production Department because it was assumed that the bulk of unreported area in remote provinces was planted with local varieties. The varietal breakdown during 1974/75, in percent was: Pelita I/1, 34.9; IR-5, 30.8; C4-63, 17.7; Pelita I/2, 11.5; IR-8, 3.0; and IR-20, 2.0. In addition to the HYV area, an estimated 739,000 ha. (or 1,826,100 acres) were planted to improved local varieties such as Syntha, Sigadis, Dewi, Ratih, and Bengawan.

[10] A significant quantity of IR-26 was planted during the dry season of 1975/76, perhaps as much as 50,000 ha. Only limited quantities of IR-28, IR-30, and IR-34 were available; IR-34 is expected to have ready acceptance when the seed is widely available. (Ref. 7.)

References

(1) Letter from Francis J. LeBeau, Chief, Agriculture Division, USAID, Djakarta, September 30, 1969 (data obtained from Ministry of Agriculture of the Government of Indonesia).
(2) Barker, *op. cit.* (June 1969).
(3) James E. Hawes, "Rice in Indonesia," Agriculture Division, USAID, Djakarta, May 1970, pp. 18, 19.
(4) Letter from Paul J. Stangel, Acting Food and Agriculture Officer, USAID, Djakarta, December 21, 1973 (data provided by the Director General of Agriculture).
(5) Letter from Leonard H. Otto, Food and Agriculture Officer, USAID, Djakarta, September 9, 1975. (Based on a Bimas report titled "Additional Information on Development of Intensification Program," Fall 1974.)
(6) "Paddy Intensification Program: Indonesia," p. 15 (data provided by Badan Pengendali Bimas, Department of Agriculture and forwarded by Peter Oram of FAO).
(7) Letter from Richard A. Morris, IRRI Representative, Cooperative CRIA-IRRI Program, Bogor, Indonesia, January 9, 1976.

Table 25—Korea (South): HYV Rice

Crop year	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1969/70	0.6[1] (1)	–	–
1970/71	–		experimental
1971/72	–	2,700	6,700 (2)
1972/73	–	187,500	463,300[2] (2)
1973/74	–	139,000	343,500[3] (2)
1974/75	–	306,900	758,300 (2) (3)
(1975/76)	–	(450,000)	(1,112,000)[4] (2) (3)

[1] 12 kg. of IR 667-08 seed harvested in Korea were planted at IRRI for increase during the winter of 1969/70. The 600 kg. of seed shipped to Korea were increased to 100 M.T. by October 1970.

[2] Tongil was planted in a number of areas which were geographically unsuited for the variety. This plus an unfavorable growing season and other factors led to a number of problems. Farmers were subsidized. (See ref. 4 for details.)

[3] See fn. 2 for reasons for drop in area.

[4] Plan figure. As of the fall of 1975, there was an outbreak of brown plant hoppers in many areas (ref. 3). A new variety, Yushin (Tongil x IR1317), was released to farmers for seed multiplication during 1975/76; it appears to have better palatability, disease resistance, and cold weather tolerance than Tongil (ref. 3).

References

(1) *The IRRI Reporter,* 1976, in press.
(2) Dong Wan Shin and Yong Kun Shim, *The Effectiveness of the Tongil Rice Diffusion in Korea,* Office of Rural Development, Suweon, 1975, Preface, p. 9.
(3) Letters from Gordon S. Nicks, Agricultural Attaché, American Embassy, Seoul, October 8, 1975, November 10, 1975.
(4) Foreign Agricultural Service Report KR-3016 from Seoul, March 14, 1973, 3 pp.; FAS Report KR-2017 from Seoul, March 22, 1972.

Table 26—Laos: HYV Rice

Crop year	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1966/67	0.1[1] (1)	360	900[4] (3)
1967/68	—	1,200	3,000[4] (4)
1968/69	6 [2] (1)	2,000	5,000[4] (4)
1969/70	—	2,000	5,000[4] (5)
1970/71	10 [3] (2)	(53,600)	(132,500)[4,5] (6)
1971/72	—	30,000	74,100[4] (7)
1972/73	—	50,000	123,600[4] (7)
1973/74	—	NA	NA
1974/75	—	NA	NA

[1] IR-8 imported from IRRI in 1966.

[2] Two M.T. each of IR-5 and IR-253 (a glutinous selection specifically chosen to suit taste preferences in the upper Mekong River basin) were imported from the Philippines in 1968. Two M.T. of IR-253 came from IRRI in 1968.

[3] IR-20 from commercial sources in the Philippines. In addition, less than 0.1 M.T. each of IR-20 and IR-22 were imported from IRRI.

[4] The approximate seasonal distribution was as follows:

	Wet	*Dry*	*Total*
		Percent	
1966/67	—	100	100
1967/68	17	83	100
1968/69	25	75	100
1969/70	25	75	100
1970/71	(97)	(3)	(100)
1971/72	94	6	100
1972/73	96	4	100

[5] The increase in wet season area is exceptionally large. It may represent the theoretical area that could have been planted (ref. 8).

References

(1) Barker (June 1969).
(2) Barker (October 1970).
(3) Department of State Airgram A-647 from Vientiane, August 15, 1969.
(4) Letter from Leroy H. Rasmussen, Agriculture Division, USAID, Vientiane, September 12, 1969.
(5) Letter from Rasmussen, September 23, 1970.
(6) Department of State Telegrams from Vientiane: 00476, January 18, 1972 and 00804, January 28, 1972.
(7) Letter from Charles A. Sanders, Chief, Agriculture Division, USAID, Vientiane, October 26, 1973.
(8) Letter from Donald R. Mitchell, Deputy Chief, Agriculture Division, USAID, Vientiane, January 4, 1974.

Table 27—Malaysia (West): HYV Rice

Crop year	Quantity of seed imported	Area planted or harvested[4]	
	Metric tons	*Hectares*	*Acres*
1965/66	3[1] (1)	42,300	104,450 (3)
1966/67	3[2] (1)	62,700	155,000 (4)
1967/68	–	90,700	224,200 (4)
1968/69	–	96,100	237,500[5] (4)
1969/70	–	132,400	327,100[5] (4)
1970/71	–[3] (2)	164,600	406,600[5] (4)
1971/72	–	197,400	487,900[5] (5)
1972/73	–	212,200	524,400[5] (5)
1973/74	–	217,000	536,300[5] (5)

[1] IR-8 imported from IRRI in 1966.
[2] IR-8 imported from IRRI in 1967.
[3] Less than 1 M.T. each of IR-20 and IR-22 imported from IRRI in 1970.
[4] Area harvested through 1971/72; planted area in subsequent years. Off-season (second) wet rice crop. Includes a number of improved hybrids. The main variety through 1968/69 was (a) Mahsuri, (Taichung 65 x Mayang Ebos 80/2) which was introduced in January 1965. Other varieties are (b) Malinja (Siam 29 x Pebifun) which was introduced in early 1950's; (c) Ria, a local name for IR-8, which was introduced in late 1966; and (d) Bahagia, which originated from the same parental cross as IR-5 (Peta x Tangkai Rotan) and was introduced in 1968. Two more varieties were introduced in 1972: Murni (Bahagia x Ria) and Masria (IR-8 x Muey Nahng 62 M). Padi Jaya (Peta x BPI 76, the same cross as C4-63) was introduced in 1973. Varieties introduced in 1974 were: Sri Malaysia Satu (Peta x Tangkai Rotan); Sri Malaysia Dua (IR-8 x Pankhari 203), and Pulut Malaysia Satu (Pulut Sutera x Ria). (Ref. 6).
[5] The varietal breakdown was as follows:

	Mahsuri	*Bahagia (IR-5 type)*	*Malinja*[a]	*Jaya (C4-63)*	*Ria (IR-8)*	*Others*	*Total*
				Percent			
1968/69	63.0	13.9	4.9	–	6.8	11.5	100
1969/70	39.7	49.5	1.1	–	2.1	7.6	100
1970/71	30.9	38.1	4.8	–	3.1	23.2	100
1971/72	39.5	43.0	3.3	–	1.5	12.7	100
1972/73	42.8	25.3	10.2	12.3	1.2	8.2	100
1973/74	31.4	17.4	13.5	9.5	0.6	27.6[b]	100

[a] Also known locally as Mat Candu.
[b] Most of the increase of this figure is believed to be composed of the other varieties listed in this table but which were not broken down in the reporting.

References

(1) Barker (June 1969).
(2) Barker (October 1970).
(3) Letter from Dale K. Vining, Agricultural Attaché, American Embassy, Kuala Lumpur, September 4, 1969 (estimate made by Attaché's office).
(4) Letters from Gordon S. Nicks, Agricultural Attaché, American Embassy, Kuala

Lumpur, October 11, 1973 and January 11, 1974. (Data from Extension and Advisory Services Division, Federal Department of Agriculture.)
(5) Letters from John S. DeCourcy, Agricultural Attaché, American Embassy, Kuala Lumpur, October 3, 1975 (data from Economic/Statistical Section, Federal Ministry of Agriculture and Rural Development), November 6, 1975.
(6) Foreign Agricultural Service Reports from Kuala Lumpur: AGR-40, March 2, 1964; AGR-36, January 1, 1965; AGR-7, August 19, 1966; AGR-69, September 10, 1968; MY-2009, March 14, 1972; MY-3017, September 25, 1973; and MY-4016, September 5, 1974.

Nepal

Table 28—Nepal: HYV Rice

Crop year	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1968/69	60.6[1] (1) (2)	42,500	105,100[4] (2)
1969/70	75 [2] (2)	49,800	123,000[4] (2)
1970/71	0.5[3] (1)	67,800	167,600[4] (2)
1971/72	—	81,600	201,700[4] (3)
1972/73	1 (3)	177,300	438,000[4] (3)
1973/74	—	205,100	506,800[4] (4)
1974/75	—	222,600	550,100[4] (4)

[1] Import of 60 M.T. of IR-8 from India and 0.6 M.T. of IR-5 from IRRI.
[2] Import of 75 M.T. of IR-8 from India.
[3] Import of 0.32 M.T. of IR-20 and 0.19 M.T. of IR-22 from IRRI in 1970 (Nepalese data list the quantities as 0.14 and 0.09 M.T., respectively; ref. 2).
[4] All improved rice.

References

(1) Barker (October 1970).
(2) Letter from Raymond E. Fort, Food and Agricultural Division, USAID, Kathmandu, October 13, 1971 (data from Economic Analysis and Planning Division, Ministry of Food and Agriculture).
(3) Letter from Philip D. Smith, Chief, Food and Agriculture Division, USAID, Kathmandu, October 17, 1973. (Area data from Department of Agriculture.)
(4) Letter from John R. Wilson, Chief, Food and Agriculture Division, USAID, Kathmandu, October 9, 1975. (Data from Department of Agriculture.)

Table 29—Pakistan: HYV Rice

Crop year	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1966/67	2[1] (1)	80	200[3] (2)
1967/68	77[2] (1)	4,000	10,000[1] (2)
1968/69	—	308,000	761,000[4] (2) (3)
1969/70	—	501,400	1,239,000 (4)
1970/71	—	550,400	1,360,000 (5)
1971/72	—	728,500	1,800,000[5] (5)
1972/73	—	647,100	1,599,000[5,6] (6)
1973/74	—	636,600	1,573,000[5,6] (6)
1974/75	—	630,900	1,559,000[5,6] (7)

[1] IR-8.

[2] IR-8; 50 M.T. were imported directly from Los Banos and another 27 M.T. were forwarded from Bangladesh where they were produced during the 1966/67 season.

[3] "Few hundred acres."

[4] Includes a "few thousand" acres of "IR-6" (Mehran 69) in the Hyderabad region; Meheran is a cross between Siam 29 and Dee-geo-woo-gen (one of the parents of IR-8).

[5] The distribution of production by province was:

	Sind	*Punjab*	*Baluchistan*	*NWFP*	*Total*
			Percent		
1971/72	68.6	28.6	2.1	0.7	100
1972/73	76.4	19.5	3.6	0.5	100
1973/74	74.4	20.0	3.4	2.3	100
1974/75	75.3	17.6	5.0	2.1	100

Almost entirely "IR-6" (Mehran 69).

[6] The decline in HYV area in 1972/73 and its subsequent leveling off was due to several factors. The most important is that the procurement price for basmati rice, which is principally raised in the Punjab and exported, is about twice as high as for the HYV's. In addition, basmati is less demanding in terms of water, fertilizer, and plant protection requirements. A shortage of water in 1972/73 and flood damage in 1973/74 also reduced HYV area. (Ref. 8.)

References

(1) "Rice and Wheat in Pakistan," Spring Review (AID), March 1969, pp. 16–17.
(2) Letter from Leon F. Hesser, Assistant Director of Agricultural Policy, USAID, Rawalpindi, October 9, 1969.
(3) Foreign Agriculture Service Telegram TOFAS 96 from Rawalpindi, October 15, 1969.
(4) "Notification," Government of Pakistan, Ministry of Agriculture and Works, Islamabad, November 11, 1970, p. 1 (enclosure to Foreign Agricultural Service Report PK-0091 from Islamabad, November 24, 1970).
(5) Data provided by S. M. A. Jafri, Statistical Officer, Planning Unit, Ministry of Agriculture and Works, Agriculture Wing, Islamabad, December 5, 1973.

(6) Letter from Alvin E. Gilbert, Agricultural Attaché, American Embassy, Islamabad, October 2, 1975. The 1972/73 and 1973/74 data were obtained from the Planning Unit of the Ministry of Agriculture.
(7) Foreign Agricultural Service Report PK-5023 from Islamabad, November 18, 1975, p. 5.
(8) Letter from Gilbert, January 12, 1976.

Table 30—Philippines: HYV Rice

Crop year	Quantity of seed introduced	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1966/67	55.3[1] (1)	82,600	204,100 (3)
1967/68	6.1[2] (1)	701,500	1,733,400[6,7] (4)
1968/69	18.2[3]	(1,011,800)	(2,500,000)[6,7,8] (4)
1969/70	— [4] (2)	1,353,900	3,345,500[6,7,9] (4)
1970/71	34.4[5] (2)	1,565,400	3,868,100[6,7] (4)
1971/72	—	1,826,800	4,514,000[6,7] (4)
1972/73	—	1,679,900	4,151,000[6,7] (4)
1973/74	—	2,176,600	5,378,400[6,7] (4)
1974/75	—	2,175,000	5,374,400[6,7] (4) (5)

[1] IR-8 purchased from IRRI in July 1966 and planted in dry season in late 1966 and early 1967.

[2] 5.2 M.T. IR-8 and 0.9 M.T. IR-5 (from IRRI).

[3] 0.1 M.T. IR-8 and 18.1 M.T. IR-5 (from IRRI).

[4] Less than 0.1 M.T. each of IR-8, IR-5, IR-20, and IR-22 from IRRI in 1969.

[5] Composed of 9.5 M.T. of IR-20 and 24.9 M.T. of IR-22, both provided by IRRI in 1970. In addition, less than a M.T. each of IR-8 and IR-5 were also provided by IRRI in 1970.

[6] The HYV area is composed of three different types of varieties. Beyond the IRRI varieties, the HYV category includes: the BPI series developed by the Bureau of Plant Industry of the Philippine Government; the C series developed by the College of Agriculture, the University of the Philippines. The principal variety in the BPI series is BPI-76; it resulted from a cross between Fortuna and Seraup Besar made in 1951 and was released in 1960; other strains with less photoperiod insensitivity were released later. The principal variety in the C series is C4-63; it resulted from a cross between BPI-76 and Peta; by 1973 one of the most common strains was C4-63G. Over time, the C series appears to have largely replaced the BPI series. The relative areas of the various HYV series were:

	IRRI	*BPI*	*C*	*Total*
		Percent		
1967/68	61.1	36.3	2.6	100
1968/69	66.5	21.6	11.8	100
1969/70	76.6	8.5	14.9	100
1970/71	71.5	3.7	24.8	100
1971/72	72.1	2.8	25.1	100
1972/73	70.0	2.3	27.8	100
1973/74	71.7	2.1	26.2	100
1974/75	75.3	1.7	23.0	100

[7] The HYV's are raised under both irrigated and rainfed (lowland) conditions. The annual HYV breakdown is as follows:

	Irrigated	*Rainfed (Lowland)*	*Total*
		Percent	
1967/68	63.7	36.3	100
1968/69	67.5	32.5	100
1969/70	61.1	38.9	100
1970/71	62.9	37.1	100
1971/72	53.5	46.5	100
1972/73	52.0	48.0	100
1973/74	54.9	45.1	100
1974/75	51.0	49.0	100

[8] Unofficial estimate. The original official estimate of the Bureau of Agricultural Economics was 1,351,800 ha. (3,340,000 acres), but this seems too high in terms of: (a) the figures for the previous and subsequent year (the area devoted to HYV's was to have increased about 20 percent in 1969/70, ref. 6), and (b) another estimate available for the same year. The National Food and Agricultural Council placed the area at 579,800 ha. (1,432,600 acres) (ref. 7), or 43 percent less than the area reported in the table and 57 percent less than the BAE figure just noted.

[9] The National Food and Agricultural Council placed the area at 950,000 ha. (2,347,500 acres), or about 30 percent less (ref. 8).

References

(1) Barker (June 1969).

(2) Barker (October 1970).

(3) *Rice in the Philippines,* Spring Review (AID), March 3, 1969, section 2, p. 6, Appendix Table VIII-B. Data from RCPCC.

(4) Official estimates of the Bureau of Agricultural Economics, Quezon City (forwarded by Robert W. Herdt, IRRI, October 2, 1975, and David E. Kunkel, USAID, Manila, October 9, 1975, February 17, 1976).

(5) Foreign Agricultural Service Telegram TOFAS 45 from Manila, February 19, 1976.

(6) Telegram from Randolph Barker, IRRI, December 14, 1970; letter from Barker, December 15, 1970.

(7) Letter from John T. Hopkins, Assistant Agricultural Attaché, American Embassy, Manila, September 25, 1970.

(8) Foreign Agricultural Service Telegram TOFAS 70 from Manila, December 3, 1970.

Table 31—Sri Lanka (Ceylon): HYV Rice

Crop year*	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1967/68	0.5[1] (1)	–	–
1968/69	211 [2] (1)	7,000	17,200[5] (3)
1969/70	– [3] (2)	26,300	65,100[5] (4) (5)
1970/71	0.4[4] (2)	30,700	75,800[6] (5) (6)
1971/72	–	70,900	175,300[6] (6) (7)
1972/73	–	231,900	572,900[6] (7) (8)
1973/74	–	368,400	910,400[6] (8)
1974/75	–	352,100	870,000[6] (8)

*Note: the crop year used in this table is different from that used in Sri Lanka. For example, Yala 1970 is combined with Maha 1970/71 here; in Sri Lanka, Maha 1970/71 is combined with Yala 1971.

[1] IR-8 (from IRRI).
[2] IR-8. In 1968, 210 M.T. of IR-8 were imported from the Philippines and 0.90 M.T. (0.45 IR-8 and 0.45 IR-5) from IRRI.
[3] In 1969, less than 0.1 M.T. of IR-20 was imported from IRRI.
[4] In 1970, less than 0.1 M.T. of IR-20 and 0.35 M.T. of IR-22 were imported from IRRI.
[5] IR-8 and IR-262.
[6] The total HYV area was divided as follows between the main varietal groupings:

	IR series[a]	*BG series*[b]	*LD-66*[c]	*Total*
		Percent		
1970/71	96.3	3.7	–	100
1971/72	41.7	58.3	–	100
1972/73	7.6	85.0	–	100
1973/74	2.3	93.9	3.8	100
1974/75	1.0	93.9	5.1	100

[a] IR-8 and IR-262 (principally IR-262).
[b] BG 3-5, BG 11-11, BG 34-6, BG 34-8, and BG 94-1 (principally BG 11-11 and BG 34-8). All are semi-dwarfs. The latter three are descended from crosses with one IRRI variety as a parent. The BG varieties have been bred specifically to suit local environmental conditions and represent four specific maturing durations to suit varying climatic conditions. (Ref. 8.)
[c] The relative importance of this variety may be overstated (ref. 8).

[7] A new variety, LD-125, has been developed from a cross between H-7 and IR-262; it is shorter than IR-8. Some of the news accounts of the performance of this variety have been exaggerated. (Ref. 9.)

References

(1) Barker (June 1969).
(2) Barker (October 1970).
(3) Letter from H. L. Dwelly, Acting USAID Representative, American Embassy, Colombo, October 2, 1969 (data supplied by Ministry of Agriculture and Food).
(4) Data supplied by Ministry of Agriculture and Food, Colombo, October 16, 1970 (forwarded by Michael H. Snyder, Assistant USAID Representative, Colombo, October 21, 1970).

(5) Data supplied by the Ministry of Agriculture and Lands, Colombo, December 10, 1970 (forwarded by Snyder, December 14, 1970).
(6) Data supplied by T. B. Subasinghe, Deputy Director for Agricultural Development, the Ministry of Agriculture and Lands, Colombo, December 9, 1971 (forwarded by Snyder, December 13, 1971).
(7) Data supplied by T. B. Subasinghe, *op. cit.*, January 25, 1974 (forwarded by H. Birnbaum, Acting USAID Representative, Colombo, January 28, 1974).
(8) Data supplied by P. Senarath, Agricultural Economist for S/A&L, Ministry of Agriculture and Lands, Colombo. December 8, 1975 (forwarded by Ernest Kanrich, USAID Representative, Colombo, December 10, 1975).
(8) Letter from Dr. H. Weeraratne, Central Rice Breeding Station, Batalagoda, Ibbagamuwa, Sri Lanka, January 7, 1976.
(9) Letter from Dr. Weeraratne to Dr. T. T. Chang, IRRI, July 14, 1975; A. B. Mendis, "High-Yield Rice Offers Hope to Hungry Sri Lanka," *Christian Science Monitor*, June 11, 1975.

Table 32—Thailand: HYV Rice

Crop year	Quantity of seed imported	Area planted or harvested[1]	
	Metric tons	*Hectares*	*Acres*
1969/70	–	(3,000)	(7,400)[2] (1)
1970/71	–	(30,000)	(74,000)[2] (1)
1971/72	–	(100,000)	(247,100)[2] (1)
1972/73	–	(300,000)	(741,000)[2] (1)
1973/74	–	(400,000)	(988,400)[2] (1)
1974/75	–	(450,000)	(1,112,000)[2,3] (1)
1975/76	–	(600,000)	(1,482,600)[2,3] (1)

[1] Unofficial estimate of area; official statistics not available. Principally RD series with some C4-63.

[2] The estimated seasonal breakdown was:

	Wet (June-Dec.)	*Dry (Feb.-June)*	*Total*
		Percent	
1970/71	90	10	100
1971/72	80	20	100
1972/73	40	60	100
1973/74	30	70	100
1974/75	20	80	100
1975/76	15	85	100

Farmers have been reverting to traditional varieties during the wet season. Nearly all the dry season rice area is planted to HYV's.

[3] It is estimated that 90 percent or more of the HYV area is planted to the RD series and not more than 10 percent is planted to C4-63 (mainly in the Central Plain) (ref. 1). In October 1975 two additional varieties, RD-7 and RD-9, were released for planting in the dry season; RD-7 has considerably greater resistance to bacterial leaf blight and better cooking quality than RD-1; RD-9 has resistance to brown plant hopper and tolerance to the rice gall midge (ref. 2).

References

(1) Letters from Guy L. Haviland, Jr., Agricultural Attaché, American Embassy, Bangkok, November 5, 1975, December 11, 1975. (Estimates provided by Dr. Ben R. Jackson, Rockefeller Foundation, Bangkok.)

(2) Letter from Dr. Ben R. Jackson, Rockefeller Foundation, Bangkok, December 30, 1975; news release provided by Dr. Jackson titled "Thai Department of Agriculture Releases Two New Rice Varieties." For early details on the Thai breeding program, see: Delane Welsch and Sopin Tongpan, "Background to the Introduction of High-Yielding Varieties of Rice in Thailand," University of Minnesota, Department of Agricultural and Applied Economics, Staff Paper 72-6, February 1972, pp. 21-25; and the articles on dwarf varieties by B. R. Jackson, et al., and A. C. Yantasast, et al., in the *Thai Journal of Agricultural Science*: 1969, pp. 83-92; 1970, pp. 119-133.

Table 33—Vietnam (South): HYV Rice

Crop year	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1967/68	45 [1] (1)	500	1,200[8] (1)
1968/69	2,005 [2] (1)	40,000	98,800 (6)
1969/70	0.1[3] (2)	204,000	504,000 (6)
1970/71	1.0[4] (3)	502,000	1,240,400 (5)
1971/72	56.0[5] (4)	674,000	1,665,400 (5)
1972/73	—	835,000	2,063,300 (5)
1973/74	2.0[6] (5)	890,000	2,199,200[9] (6)
1974/75	[7]	(900,000)	(2,223,900)[10] (6)

[1] IR-8; imported in October 1967. This shipment is noted in an AID report (ref. 1) but not in IRRI listings (which cite only shipments of less than 0.1 M.T. of IR-8 and IR-5; ref. 7).

[2] 2,000 M.T. of IR-8, 5 M.T. of IR-5. Barker indicates that the Philippines exported 1,807 M.T. of IR-8 and 205 M.T. of IR-5 to Vietnam (ref. 7). The reason for the difference in varietal composition is not known.

[3] 143 lbs. (65 kg.) of IR-20 received from IRRI in June 1969.

[4] IR-22 from IRRI, 1970. In addition, less than 0.1 M.T. of IR-20 seed was received from IRRI.

[5] Of this, 55 M.T. were IR-20 imported from the Philippines in March 1971 (50 M.T. were distributed to farmers in flood ravaged provinces; 5 M.T. were registered seed and were distributed for certified seed production) while 1 M.T. of RD-1 was imported from Thailand as a possible replacement for IR-5 (known locally as TN-5).

[6] IR-26. 35 M.T. of certified IR-20 were exported to Cambodia in July 1973.

[7] 10 M.T. of IR-20 were exported to Cambodia in January 1975.

[8] Area planted. Only about 134 ha. (330 acres) were harvested because of poor rains.

[9] Of this total, perhaps 500,000 ha. (1,236,000 acres) were composed of IR-20. Much of the remaining area was planted to IR-5, IR-8, and C4-63.

[10] Unofficial estimate. Area planted to IR-20 dropped from previous year; replaced by IR-26 and TN 73-2 (an IRRI selection identified by Vietnamese researchers).

References

(1) *Rice in South Vietnam,* Spring Review (AID), March 12, 1969 (TOAID A-1357), pp. 2, 8, 15, 16, 17.

(2) Agricultural Production Memo, Rice Series No. 117, Office of Domestic Production, USAID, Saigon, January 6, 1970. Also noted in Department of State Airgram TOAID A-5406 from Saigon, October 31, 1970, p. 5.

(3) Barker (October 1970).

(4) Agricultural Production Memo, Rice Series No. 140, Office of Food and Agriculture, USAID, Saigon, May 25, 1971, pp. 1–5; letter from Ralph W. Clark, Agricultural Production Division, Office of Food and Agriculture, USAID, Saigon, November 20, 1971.

(5) Letter from C. T. Brackney, Agronomy Advisor, Rice, Office of Food and Agriculture, USAID, Saigon, November 7, 1973. The 1970/71 data were based on records of the Rice Service; beginning in 1971/72, data were obtained from the somewhat more conservative Directorate of Agricultural Economics.

(6) Conversations with C. T. Brackney, Washington, D.C., August 14, 15, 1975. Area data for 1973/74 from Directorate of Agricultural Economics; 1974/75 data are estimates.

China has long been the world's largest rice producer. Accordingly, it has the longest history of rice improvement and progressive cultivation.[1] As in other countries, much improvement occurred as farmers simply selected improved varieties which were then used locally. The major characteristics of this process were outlined in Chapter II.

Both indica and japonica (sinica or keng) rices are found in China. Most varieties grown in southern China have traditionally been indicas. Both types are grown in the area bordering the Yangtze River in east China.[2]

Irrigation and fertilization of rice have long been practiced in China. Through most of history, the fertilizers were organic products such as compost, green manures, oil meals, fish cakes, and night soil. The development of quick-acting chemical fertilizers promised a much sharper boost for varieties which could respond to their application and yet not lodge. Such fertilizers, however, were not widely adopted in China until the 1960's.[3] They subsequently had a significant effect on agricultural production. Fertilizer-responsive rice varieties also played a key role.[4]

Stalk strength is a particularly important factor in the southern portions of China, especially in Kwangtung Province, because the early crop matures during the first part of the typhoon season. Accounts of the early development of dwarf rice in Kwangtung vary slightly.

One account says the parent of the most widely used early rice variety was found by two peasants in 1956 in an eastern Kwangtung field which was otherwise flattened by a typhoon; the first promising cross breed was obtained in 1959.[5] Distribution of a dwarf "Nanteh" variety (I-geo Nan-teh) began in 1961. Six strains of dwarf rice were successfully developed between 1959 and 1963.[6]

Another recent account has it that the dwarf variety (Ai-Tze-Tzang) was found in a farmer's field in Kwangsi (west of Kwangtung). It was crossed with a local variety of normal height in Kwangtung Province in 1956. In 1960, one of the selections from this cross, Kuang-ch'ang-ai, was released. In 1961, the Chen-chu-ai variety was released; this was followed by Canton Liberation No. 9 in 1964.[7]

In addition, the province of Fukien appears to have played a role in the

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[1] T. T. Chang, "The Rice Cultures," *Philosophical Transactions of the Royal Society of London,* Series B, in press.

[2] T. H. Shen, *Argicultural Resources of China,* Cornell University Press, 1951, p. 197.

[3] Dwight H. Perkins, *Agricultural Development in China, 1368–1968,* Aldine, Chicago, 1969, pp. 60–76.

[4] Dwight H. Perkins, "Constraints Influencing China's Agricultural Performance," Harvard University, Institute of Economic Research, Discussion Paper No. 407, April 1975, pp. 15, 18.

[5] Foreign Agricultural Service Report HK-2036 from Hong Kong, June 2, 1972, p. 4.

[6] Based on comments provided by Yeuh Tung, Office of the Agricultural Officer, American Consulate General, Hong Kong, September 23, 1970.

[7] Based on information provided by the Kwangtung Academy of Agricultural Sciences and reported in *Plant Studies in the People's Republic of China: A Trip Report of the American Plant Studies Delegation,* National Academy of Sciences, Washington, D.C., 1975, pp. 52–53.

development of semi-dwarf rice. It is reported that at least some of the short-stalk strains developed in eastern Kwangtung were from a parent variety native to Fukien Province. Similarly, to the immediate north in Kiangsi Province, a short-stemmed rice (Bantam Nan 4) was introduced from Fukien in early 1964. Dee-geo-woo-gen, one of the parents of TN-1 and IR-8, is thought to have come from Fukien.

Large-scale dissemination of dwarf, high-yielding varieties began in 1964. By 1965, a total of about 4.3 million ha. (10.6 million acres) were reportedly planted. This was 13 percent of the total rice area in the country. The main varieties were: Nung-k'en 58 (26 percent of the total), Chen-chu-ai (17 percent), Ai-chiao-nan-t'e (17 percent), and others (40 percent). Adoption of these varieties (with Chiang-nan-ai substituting for Nung-k'en 58) was particularly rapid in Kwangtung. By 1965, about 1.5 million ha. (3.7 million acres) were reportedly sown; this accounted for two thirds of the early crop. In Kiangsu, about 0.63 million ha. (1.6 million acres) were planted to Nung-k'en 58 in 1965. High-yielding varieties were also heavily planted in Fukien and Hunan provinces.[8]

The subsequent role of improved varieties appears to have been substantial. Some accounts indicated that they continued to be extensively planted in Kwangtung in the late 1960's.[9] Several radio accounts and visitors in 1969 mentioned dwarf, high-yielding varieties.[10] Record rice yields reported in China in 1969 were attributed to the introduction of new varieties.[11] By 1970, dwarf varieties were reportedly extensively used in all early rice producing provinces (the area of early rice accounts for about one quarter of the total rice output in China).[12] In late 1974, the Chinese Academy of Agricultural and Forestry Sciences indicated that 80 percent of the rice grown in south China is short statured and stiff-strawed.[13] It has recently been suggested that as of 1973, a total of 6.7 million ha. (16.6 million acres) were planted to high-yielding varieties.[14]

Until recently, it was a tantalizing question whether the IRRI varieties played any role in recent Chinese developments. For several years, the Chinese said nothing about this and Western news accounts were mixed.[15]

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[8] Benedict Stavis, *China's Green Revolution,* Cornell University, East Asia Papers, No. 2, January 1974, pp. 20–27. Another source places the dwarf area in Kwangtung at nearly 1 million acres in 1964 (or about half the total rice area); by 1965, the dwarf area represented more than 80 percent of the total (Tung, *op. cit.*).

[9] Stavis, *op. cit.*, p. 25.

[10] Tillman Durdin, "Chinese Report New Rice Strain," *New York Times,* October 26, 1969; "Two Big Harvests Reported in China," *New York Times,* November 19, 1969.

[11] "Two Big. . . .," *op. cit.*

[12] Tung, *op. cit.*

[13] *Plant Studies in the People's Republic. . . , op. cit.*, p. 48.

[14] Ben Stavis, "A Preliminary Model for Grain Production in China, 1974," *The China Quarterly*, March 1976, p. 87 (based on "New Achievements in Rice Research," *Peking Review,* February 8, 1974. p. 22).

[15] Several reporters pointed out the similarities between the IRRI and Chinese varieties, but went no further. Only one writer is known to have actually said that IR-8 was being used in China; he indicated that the Chinese began their first experiments with the seed in 1968, and then placed orders for seed through proxies in Nepal and Pakistan for spring planting in 1970. (Richard Hughes, "China Samples the Rockefeller Rice," *London Sunday Times,* February 15, 1970 [reprinted as "Superior

The first official confirmation was provided to the American Plant Studies Delegation, which visited China in August and September, 1974. The Kwangtung Academy of Agricultural Sciences revealed that IR-8 came into that Province in 1967 and was planted in 1968. Its growing season proved too long to fit the multiple cropping patterns of the area and it was not sufficiently cool-tolerant or resistant to bacterial leaf blight. IR-8 has been used, however, in breeding programs because of its stiff straw and high-yielding ability. IR-8 was also said to have been introduced in Shensi Province in 1971 but again the growing season proved to be too long. Other IRRI varieties tested in Kwangtung include IR-20, IR-22, IR-24, and IR-26; none, however, fit the growing season requirements.[16] Similar IRRI variety results have been obtained in Nanking and Shanghi. The source of several of these more recent varieties is clear: in late November 1973, Philippines President Marcos presented 1 M.T. of IR-20 and one sack of IR-26 to a visiting Chinese trade delegation. The gift was reportedly in response to a request from Premier Chou En-Lai. The delegation also visited IRRI.[17]

The main contribution of the IRRI varieties in China would appear to be as a parent in future breeding programs.

Rice Strain is Sold to Red China," *Chicago Tribune,* May 6, 1970]. Hughes subsequently indicated [letter, September 21, 1970] that he had confirmed the report with a contact in Peking).

[16] *Plant Studies in the People's Republic. . . , op. cit.*, pp. 50–53. Press accounts based on this study were reported in the *New York Times* on September 24, 1974 and October 7, 1974. Also see *The IRRI Reporter,* 4/74, pp. 1–2.

[17] "China–IRRI Rice Research," *Times Journal,* Manila, December 1, 1973, pp. 1, 10. Also see *The IRRI Reporter,* 4/74, pp. 1–2.

North Vietnam

Short-season rice strains were introduced in the mountain areas of North Vietnam in 1948. They were classified as a *spring* rice (planted in the spring and harvested in the summer) and their short growing period made it possible to plant them after the traditional fall crop (10-month rice). By 1954, some 5,000 ha. (12,400 acres) of spring rice were planted in the mountain regions.

Beginning in 1957, steps were taken to introduce spring rice into the midlands and delta areas where the traditional fifth month rice (*chiem*) was not well suited. Early efforts were not very successful and, by 1965, the total spring rice area in North Vietnam had dropped to 3,700 ha. (9,100 acres). Thereafter, however, appropriate cultural methods were developed and the area of spring rice expanded sharply:[1]

	Hectares	*Acres*
1966	23,700	58,550
1967	25,050	61,900
1968	34,500	85,250
1969	63,250	156,250
1970	103,650	256,100
1971	540,000	1,334,300
1972	650,000	1,606,150

While the early spring varieties had a short growing season, they were not classified as high-yielding. Reportedly, *new strains* with short stems and short growth duration were "created" in 1966-1967 "after long and patient agronomical researches."[2] During the 1969/70 winter-spring season, about 18.5 percent of the spring rice area was planted to new varieties. By 1970/71, this had increased to 58 percent.[3] By the 1971/72 season, the proportion was placed at 65 to 70 percent.[4] The subsequent level of use is thought to have remained in this range. Since the spring crop now accounts for about 58 percent of the annual crop, this means that from 38 to 41 percent of the total rice area is planted to the improved varieties. In addition, some of the 10-month crop is sown to improved varieties.

Two of the most important improved varieties are Nong Nghiep (Agriculture) 5 and Nong Nghiep (Agriculture) 8. As of September 1969, the two were reported "growing experimentally over large areas."[5] A

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[1] "Spring Rice," *Viet Nam Courier,* Hanoi (in English), October 1972, p. 19. Other details are provided in "Spring Rice Has Good Prospects in Vietnam," *Khoa Hoc Thuong Thuc,* Hanoi (in Vietnamese), February and March 1970 (JPRS 50693, June 9, 1970).

[2] *Ibid.*, p. 20. Varieties mentioned were Tran Chau No. 2 and No. 4.

[3] "New Varieties, New Productivity," *Nhan Dan,* Hanoi (in Vietnamese), February 22, 1972, p. 2 (JPRS, 55745, April 18, 1972).

[4] "Fertilizing Rice," *Nhan Dan,* March 20, 1972, p. 2 (JPRS, 55894, May 4, 1972); "Develop Winter-Spring Production," *Nhan Dan,* March 22, 1972, pp. 1, 4 (FBIS, April 5, 1972).

[5] Nguyen Van Luat, "Prospects for Short-Term Rice in Vietnamese Agriculture," *To Quoc,* Hanoi, September 1969, pp. 24-26 (JPRS, 49482, December 19, 1969).

subsequent newspaper account indicated that emphasis was being placed on IR-8; the seed was allegedly obtained "through Hong Kong and elsewhere."[6] In December 1972, Nong Nghiep 8 was reported to be the predominant spring variety.[7] Both it and Nong Nghiep 5 also appear to be the principal new varieties used during the 10-month crop.[8] A new variety, A2, is "treated, selected, and nurtured from the IR-8 variety." A2, in turn, is also one of the parents of A3 and A4.[9] IR-5 and IR-8, therefore, appear to have been of considerable significance in North Vietnam.

No recent references to the use of HYV rice in North Vietnam have been found. However, a January 1976 news release from Hanoi indicates that increased use is to be made of winter sowing of crops to produce a third harvest. In order to be able to do this, the news account indicates, "it is necessary to introduce special sorts of seed, especially rice, of which vegetation is shorter than 4 months".[10]

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[6] George McArthur, "N. Vietnam Reaping Record Rice Crop," *The Washington Post,* August 19, 1971, p. F2.

[7] "Seeds and Seedlings," *Nhan Dan,* December 18, 1972, pp. 1, 4 (JPRS, 58128, February 1, 1973).

[8] "Establishing the Correct Allocation of 10th Month Rice," *Nhan Dan,* May 22, 1973, p. 2 (JPRS, 59449, July 6, 1973).

[9] "Scientific and Technical Activities News Column," *Tap Chi Hoat Dong Khoa Hoc,* Hanoi, December 1972, pp. 42–43 (JPRS, 58335, February 27, 1973). This is the first direct Vietnamese reference to IR-8 observed.

[10] News release, in English, from Tanjug news agency, Belgrade, January 3, 1976 (provided by Robert Svec, Agricultural Attaché, American Embassy, Belgrade, January 22, 1976).

NEAR EAST

Rice is a relatively minor crop in the Near East. Egypt is the leading producer, followed by Iran, Afghanistan, and Iraq. Semi-dwarf HYV's have been used to a limited extent in Egypt and Iraq, but evidently not in the other countries in the Near East.[1]

Egypt

IRRI varieties have been under test in Egypt for a number of years. IR-8 was introduced in 1967, but was rejected because of relatively late maturity and unpopular grain quality. Subsequently, in 1973, IR-22 and its sister line IR 579-48 were reported to be the most promising introductions; they were undergoing final yield and seed multiplication tests.[2] By 1975, about 6,800 ha. (16,800 acres) were planted to IR-22 and IR-579.[3] Sakha 1 and Sakha 2 have been named from IRRI selections.[4] One drawback of most of the IRRI material is its greater susceptibility to the stem borer than local varieties such as Nahda. The IRRI varieties have also been used for crossing with local varieties; hybrid 236-21 is one such product.[5]

Iraq[6]

IR-8 was introduced into Iraq in 1969 and IR-22 in 1975. The areas planted to these two varieties in recent years are estimated to be:

Crop year	*HYV area*	
	Hectares	Acres
1972/73	5,000	12,400
1973/74	12,000	29,700
1974/75	15,000	37,100

[1] Iran has recently introduced two new varieties which reportedly have high-yielding characteristics: Amol I and Mehr. It is not known whether they are semi-dwarfs. Perhaps 20,000 ha. (49,400 acres) were planted in 1975/76. (Foreign Agricultural Service Report IR-5009 from Tehran, May 8, 1975, p. 3.)

[2] M. S. Balal: "Rice Production in Egypt," "Breeding Rice Varieties for Higher Productivity," FAO/SIDA Seminar, Cairo, September 1973, pp. 73, 215.

[3] Letter from R. Gerald Saylor, The Ford Foundation, Cairo, October 29, 1975 (data from the Institute of Agricultural Economics, Ministry of Agriculture).

[4] Letter from T. T. Chang, IRRI, March 10, 1976.

[5] H. A. El-Tobgy, *Contemporary Egyptian Agriculture,* The Ford Foundation, Beirut, January 1974, pp. 107–109.

[6] Data provided by N. Erus, Chief, Basic Data Unit, Statistics Division, FAO, Rome, January 19, 1976.

AFRICA

Rice traditionally has not been a major crop in Africa, but it is becoming increasingly important, particularly in West Africa. Before the 19th century, the local rices belonged to the African cultivated species, *Oryza glaberrima.* In favored areas the African rices have been rapidly replaced by *O. sativa* varieties introduced principally from tropical Asia.[1]

IR-8 was imported by the Ivory Coast and Liberia as early as 1967; IR-5 and C4-63 seed followed in 1968 (and was also imported by Ghana). Although these and other semi-dwarf varieties are under study in a number of African nations, as of 1975/76 they do not yet appear to have found widespread commercial use. It is, however, difficult to be certain; official area estimates are still largely nonexistent.

From what is known, it appears that the IRRI varieties were generally not as well adapted in Africa as in many areas of Asia because of insect and disease problems (principally blast) and widely varying cultural conditions (including mangrove, deeply flooded, and upland conditions). But some IRRI varieties have done well in certain irrigated locations. Once problems of adaptation are solved, the potential for expanded production of HYV rice would appear to be substantial, especially in newly reclaimed areas along rivers.

Varietal research is being conducted by the International Institute for Tropical Agriculture (IITA) in Nigeria, both at its own headquarters and in several cooperative country programs. Considerable testing of improved varieties is being done under the auspices of the West African Rice Development Association (WARDA). WARDA intends to begin to gather information in 1976 on the area planted to improved varieties.

In the interim, all we have to offer is some notes on activities in nine African nations. These are based partly on observations recorded in the previous HYV report (July 1974), which were provided by Dr. J. C. Moomaw, then with IITA. Further bits of information have been obtained from AID agriculture officers, USDA agricultural attachés, and an unpublished report of a trip to research stations in West Africa by Dr. Robert F. Chandler, Jr. in the fall of 1975. The HYV's have also been introduced in Madagascar (Malagasy Republic) and perhaps in other African nations.

Cameroon[2]

In 1970, several hundred hectares of IR-8 rice were planted in West Cameroon but, due to a variety of problems, they have practically disappeared.

In late 1975, however, it was estimated that between 400 to 500 ha.

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[1] T. T. Chang, "Rice," in *Evolution of Crop Plants* (N. W. Simmons, ed.), Longman, London, 1976, pp. 98-104.

[2] Letter from M. H. Ford, Agricultural Advisor, USAID (Area Development Office for Central Africa), American Embassy, Yaounde, Cameroon, November 7, 1975.

(1,000 to 1,240 acres) of IR-20 and IR-24 were being grown in an irrigated rice project at Yagoua. Other varieties grown include Taichung 178 and D114H. IR-22 was tried but was wiped out by neck blast. A number of rice development projects are underway and the prospects for HYV's are considered quite promising if appropriate insect and disease resistance characteristics can be developed.

Ghana[3]

The first HYV grown in Ghana appears to have been C4-63; it was evidently first grown in 1969, but proved susceptible to blast. During 1972-74, IR-20 and IR-5 were introduced. A substantial area of IR-20, perhaps 1,200 ha. (3,000 acres) or more, was estimated to have been raised in 1973. IR-5 did not do as well as IR-20 in 1974, but reportedly did as well or better in 1975. CICA-4 is also successfully being raised. The most promising new variety at the moment is IR-442 (IR95-31-4 x Leb Mue Nahng). It can stand up to 1-meter water depth and can perform well in upland culture on a fertile and wet soil.[4]

Ivory Coast

The Centre de Semence (Center for Seed Multiplication and Improvement) was cooperatively established in 1967 at Dabou by the National Government and an agricultural technical mission from Taiwan. From IRRI lines, the Center selected and named seven varieties: CS-1 through CS-7. In 1972, with the assistance of the European Development Fund (FED), the National Government established the SODERIZ (Société Pour le Developement de la Riziculture) seed company. Seeds of IR5, IR8, and CS-5 (IR506-1-36), CS-6 (IR480-14), Taipei-309 and Chianan-8 were multiplied and distributed: 57 M.T. in 1972 and 94 M.T. in 1973.[5]

A number of cooperative programs, involving thousands of acres, are underway to improve and expand rice culture. One major effort, financed by FED, is being undertaken in swamp areas in the north; about 70 percent of the area is planted to IR-5 and 30 percent to IR-8.[6] Significant quantities of these two varieties have also been planted in the Yamassukro area. Altogether, perhaps 3,000 ha. (7,400 acres) were planted to high-yielding varieties including Jaya in the 1973-74 period.[7]

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[3] Letter from Oleen Hess, Food and Agriculture Officer, USAID, American Embassy, Accra, Ghana, October 17, 1975; Chandler, *op. cit.*; Moomaw, *op. cit.*

[4] Letter from T. T. Chang, IRRI, February 23, 1976.

[5] M. T. Tzen, "Improvement of Lowland Rice Varieties in Ivory Coast" (in Chinese), *Sci. Agr. Soc.*, Taipei, 1975 (excerpted by T. T. Chang, IRRI, letter, March 10, 1976).

[6] Letter from M. Rossin, Le Director Technique, Société Pour le Developement de la Riziculture (SODERIZ), Abidjan, February 22, 1974.

[7] Letter from John E. Riesz, Agricultural Attaché, American Embassy, Monrovia, Liberia, April 23, 1974.

Liberia[8]

Liberia grows very little paddy rice but has a substantial area of upland rice. The semi-dwarf HYV's do not appear to be widely used. Farmers prefer a variety with longer straw. A locally selected variety, LAC-23, was planted on about 12,000 ha. (30,000 acres) in the 1973-74 period. IITA has a cooperative rice improvement program with the central Experiment Station at Suakokò; the emphasis is on upland rice improvement.

Nigeria[9]

IITA has supplied about 2 M.T. of IR-20 seed multiplied from stock brought from IRRI by Dr. J. C. Moomaw in 1970. Some plantings (those in Lake Chad District) failed because of the drought but others (such as on the Jos Plateau in the eastern States) did well. Moomaw estimates that perhaps 500 to 600 ha. (1,200 to 1,500 acres) of the IRRI varieties were being raised in 1973. In the fall of 1975, Chandler noted that while the shorter IRRI varieties did not appear to do well under upland conditions ("often growing to a height of no more than 50 to 60 cm."), the same semi-dwarf varieties were doing quite well under lowland conditions, providing they were resistant to the West African races of the rice blast disease. IITA is carrying out a rice improvement program with Nigeria under USAID funding.

Senegal[10]

As of 1973, substantial areas of IR-8 were thought to be growing where irrigation water was available along the Senegal River. During the 1974/75 season, 20 M.T. of Jaya seed were imported from India. As of early 1976, TN-1 was reportedly raised on about 3,000 ha. (7,400 acres) and a substantial area was planted to early-maturing Chinese varieties (6044, Tchen Tchou Way, Kuang Sisuan). A new experiment station for research on rice and other irrigated crops is under development at Fanaye.

Sierra Leone[11]

Sierra Leone has not moved strongly in the direction of dwarf rices

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[8] Letters from Riesz, *op. cit.*, April 23, 1974, September 19, 1974; *IITA Annual Report, 1974,* pp. 177-179. LAC is an acronym for Uniroyal's Liberia Agricultural Company.

[9] Moomaw, *op. cit.*; Chandler, *op. cit.*; *IITA Annual Report, 1974,* pp. 177, 179-180.

[10] Moomaw, *op. cit.*; Chandler, *op. cit.*; letter from Victor Lateef, Regional Agricultural Officer, USAID, American Embassy, Dakar, Senegal, September 25, 1975; letter from Robert C. Tetro Jr., Assistant Agricultural Attaché, American Embassy, New Delhi, November 28, 1975; letter from Robert E. Haresnape, Agricultural Attaché, American Embassy, Monrovia, April 26, 1976.

[11] Moomaw, *op. cit.*; *IITA Annual Report, 1974,* pp. 177, 179.

because of disease problems, toxic soil factors, and the heavy plantings of upland rice. Nevertheless, the Nationalist Chinese, before they left in 1972, had a planting of about 60 ha. (150 acres) of IR-5 or a Taiwan variety on the Little Scarcies River below Mange. There is also said to be a substantial acreage of HYV's in the Kenema District. IITA is conducting a cooperative rice improvement program with the Rice Research Institute at Rockupr, where USAID is providing funds for the improvement of facilities.

Zaire[12]

The first major rice improvement work in Zaire was carried out from 1968 to 1972 by a team of rice specialists from Taiwan. In 1973, the rice development work was taken over by a team from the People's Republic of China. The PRC team is evidently carrying out this program in the town of Bumba in northern Zaire along the Zarian river. By the fall of 1975, four experimental fields had been established with a total area of 42 ha. (104 acres). Three pilot villages and six secondary villages were designated for multiplication purposes. North Koreans are expected to assist with the seed multiplication. Technicians were reportedly working with a combination of Asian, American, and Philippine varieties for crossing with Zarian rice. The PRC contract ends in 1978.

[12] Foreign Agricultural Service Reports from Kinshasa: ZR-5019, September 26, 1975; ZR-5002, January 30, 1975, p. 4.

LATIN AMERICA

Compared to Asia, rice is not of major importance in Latin America, but it is planted over a greater area than in Africa. The major producer, by a very wide margin, is Brazil, followed at some distance by Colombia, Mexico, and Venezuela.

HYV's of rice are raised in most, but not all, of the rice producing nations in Latin America. They are generally found in upland areas in Central America and irrigated areas in South America. In the long established rice growing areas, HYV's have largely replaced improved varieties.

The data on area planted to the HYV's in Latin America are not yet historically complete or fully developed. Such data as have been found are summarized here.[1] In addition to the 12 countries listed, HYV rice is raised in significant quantities in Guatemala and Panama (variety delineations and area figures for these countries, however, were too uncertain and limited to warrant reporting them in further detail).[2] Seasonal classifications are not entirely consistent among the countries listed.

Still, as of 1974 or 1974/75, it appears that a total of about 770,000 ha. (1.9 million acres) of HYV rice were raised in the Latin American countries reported in this section (excluding Cuba).[3]

There is considerable room for expansion of HYV area as irrigated areas along rivers are developed. The main constraint may be insufficient demand for rice.

Brazil

Research on rice in Brazil began in 1937 with the establishment of a rice experiment station about 10 miles from Porto Alegre in the State of Rio Grande do Sul. In 1959, the station (then operated by the Instituto Rio Grandense do Arroz) released its first hybrids (as part of a series designated EEA). About 95 percent of the rice land in Rio Grande do Sul is irrigated, providing a good setting for the use of the semi-dwarf varieties.[4] Many are under test.[5] It is estimated that the area planted to

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[1] In preparing this section, I have benefited from a continuous dialogue with Grant Scobie of the Centro Internacional de Agriculture Tropical (CIAT), Cali, Colombia, who was engaged in a parallel effort. Our data do not always fully agree, in part from the use of different sources and possibly different varietal classifications. Peter Jennings of the Rockefeller Foundation reviewed an earlier draft and was of help on a number of points. Dr. T. T. Chang of IRRI was also of assistance.

[2] The area of CICA-4 and CICA-6 in Panama in 1974 appears to have been about 5,100 ha. (12,600 acres) (letter from Grant Scobie, CIAT, March 11, 1976).

[3] In the previous edition of this bulletin, I suggested that in 1972/73 the total HYV area for 11 countries (excluding Cuba) may have been about 429,600 ha. (1,061,400 acres).

[4] *Rice in Rio Grande do Sul*, Instituto Rio Grandense do Arroz (IRGA). Porto Alegre, 1970, unnumbered (provided by Edmond Missiaen, Assistant Agricultural Attaché, American Embassy, Brasilia, September 25, 1975).

[5] Current details are provided in the monthly magazine, *Lavoura Arrozeira*, IRGA,

such varieties (principally CICA-4) in Rio Grande do Sul totaled about 330 ha. (830 acres) in 1973/74, 3,000 ha. (7,400 acres) in 1974/75, and perhaps 35,000 ha. (86,500 acres) in 1974/75.[6]

Elsewhere in Brazil, rice is more typically grown in unirrigated areas and relatively little information on the use of semi-dwarfs is available.

Colombia[7]

Rice improvement work began in Colombia in 1957. Several improved varieties were released by the Instituto Colombiano Agropecuario (ICA): Napal, ICA-10, and Tapuripa. In 1967, ICA turned to the development of semi-dwarf varieties and joined forces with the rice program of the newly established International Center for Tropical Agriculture (CIAT).

In 1966, IR-8 was introduced from IRRI for use in irrigated tropical areas. This was followed by the release of IR-22 and CICA-4 in 1971, and CICA-6 in 1974. All were recommended for irrigated lands. Estimates of the area planted to these varieties follow:

Year	Total HYV area		Proportion of HYV area planted to				
			IR-8	IR-22	CICA-4	CICA-6	Total
	Hectares	*Acres*			*Percent*		
1968	(100)[a]	(200)[a]	100	—	—	—	100
1969	(9,300)[a]	(23,000)[a]	100	—	—	—	100
1970	(41,000)[a]	(103,500)[a]	100	—	—	—	100
1971	(66,600)[a]	(164,600)[a]	76.3	9.1	14.6	—	100
1972	125,400	309,700	39.9	21.4	38.7	—	100
1973	165,800	409,700	35.3	42.6	22.1	—	100
1974	270,800	669,100	(39.7)[b]	(33.1)[b]	(27.1)[b]	(0.1)[b]	100

[a]Estimated.

[b]Based on composition of seed sales by Fedearroz.

By 1974, virtually all (99.2 percent) of the irrigated area had been planted to semi-dwarfs.

Porto Alegre. The Nov.-Dec. 1976 issue describes a promising new strain: IRGA-408 (IR-930-31-10; equivalent to CICA-4).

[6]Estimate provided by Grant Scobie, CIAT. In the past IRGA has provided a variety breakdown in its annual statistical report and while this report did not list CICA-4 or any IRRI varieties in 1974, presumably these would be picked up in the future.

[7]This section is partly based on: comments provided by Peter Jennings, Rockefeller Foundation; Reed Hertford, Jorge Ardilla, et al., "Productivity of Agricultural Research in Colombia," in *Resource Allocation and Productivity in National and International Agricultural Research* (ed. by T. M. Arndt, D. G. Dalrymple, and V. W. Ruttan), University of Minnesota Press, 1976, in press (estimates converted from proportion of total area to proportion of HYV area). Estimates of 1971/72 HYV area provided by the office of Dr. Manuel Rosero, ICA. The 1972/73 data were obtained from *Programa Nacional de Arroz, Informe Anual de Progreso 1973,* ICA, pp. 1, 3, 4.

The rice blast disease is a constant threat and the hoja blanca virus, presently controlled by varietal resistance, could again become a significant yield restraint.

Costa Rica

Semi-dwarf varieties found early and rapid adoption in Costa Rica. By 1975, about 96.2 percent of the total rice area was planted to HYV's mostly in nonirrigated areas (very little cropland is irrigated). Yearly estimates of the HYV area are as follows:[8]

Year	HYV area	
	Hectares	*Acres*
1970	16,000	39,500
1971	22,900	56,600
1972	50,000	123,600
1973	55,500	137,100
1974	64,200	158,600
1975 (est.)	81,600	201,600

The varietal breakdown is not entirely clear. Rather scattered data suggest that as of:[9]

- 1971/72, the HYV area was entirely composed of IRRI varieties.
- 1972/73, the breakdown was roughly: IR-8, 35 percent; IR-22, 34 percent; CICA-4, 15 percent; and others, 16 percent.
- 1973/74, over 90 percent of the HYV area was reportedly planted to CICA-4.
- 1974/75, the area was largely planted to CR-1113, selected from IR-822-81-2 at CIAT.

The switch to CR-113 was prompted by the susceptibility of the other varieties to blast.

Cuba

The semi-dwarf HYV's of rice got off to an early start in Cuba, but very little is known of their current status.

It appears that Cuba originally obtained 1 kg. of IR-8 seed from Mexico

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Data for 1974 were obtained from Grant Scobie, CIAT, November 20, 1975. Details about CICA-6 are provided in the *CIAT Annual Report, 1974,* pp. 211 and 212.

[8] Based on estimates provided by Grant Scobie, CIAT.

[9] The 1971/72 and 1972/73 figures are based on data reported in the previous edition of this bulletin. The 1973/74 breakdown was provided by Alberto Vargas, Sub-Director, Investigaciones Agricolas, Ministerio de Agricultura y Granaderia, San José to Milton Lau, USAID, San José, October 17, 1973. The 1974/75 estimate was provided by Peter Jennings, Rockefeller Foundation.

and did the multiplication themselves.[10] A Cuban newspaper stated in December 1968 that the seed was obtained only after much difficulty.[11] Two Cuban officials visited IRRI in March 1969 and obtained small seed samples of 26 experimental lines.[12] Production of certified seed was scheduled to begin during the winter of 1970/71.

As of the early 1970's, IR-8 rice was rather widely planted in Cuba. Of the area planted in the "spring campaign" as of late May 1970, 91 percent or about 94,700 ha. (234,000 acres) was reportedly IR-8.[13] Sinaloa A68, an IRRI selection from Mexico, was also grown.

The current HYV area is simply not known. One estimate suggests that in 1974 about half of the total area or about 80,000 ha. (198,000 acres) was planted to HYV's.[14] In view of the area figure cited above for 1970, this would seem to be a very conservative figure.

Dominican Republic

IR-8 rice was introduced in the Dominican Republic in December 1966. Other lines and varieties followed.[15] A variety known as Juma 57 was obtained by crossing IR-8 with Nilo.[16] CICA-4 was renamed Avance 72. Virtually no data appear to be available, however, on the area planted to HYV's or the varietal composition. One rough early estimate suggested that about 15 percent of the area in 1972/73 (perhaps 10,000 ha. or 25,000 acres) was planted to identified HYV's.[17]

Ecuador[18]

While the HYV's have been raised in Ecuador since the early 1970's, there is some question about their actual area. This is partly a definitional problem. If the HYV's are defined as IR-8 and INIAP-6 (CICA-4), the following data may be derived:

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[10] Letter from D. S. Athwal, Assistant Director, IRRI, May 21, 1971 (based on comments by Dr. R. F. Chandler).

[11] Rene Camacho Albert, "Rice Plan, Self Sufficiency in 1971 in Oriente," *Granma* (Havana, in Spanish), December 21, 1968, p. 5.

[12] Athwal, *op. cit.*

[13] "The Spring Campaign Reaches 7,663 Caballerias of Rice," *Granma* (Havana, in Spanish), June 1, 1970.

[14] Grant Scobie, CIAT, December 15, 1975.

[15] *Comportamiento del IR-8 en la Republica Dominica,* Secretaria de Estado de Agricultra, 1969, 12 pp.

[16] Letter from L. R. Fouchs, Agricultural Attaché, American Embassy, Santo Domingo, October 11, 1973. About 350 ha. (864 acres) of Juma 57 were planted in 1972.

[17] *CIAT Annual Report, 1972,* p. 160.

[18] Letters from C. Milton Anderson, Agricultural Attaché, American Embassy, Quito, December 1, 1975 and January 14, 1976 (data developed in cooperation with the National Agricultural Research Institute of Ecuador). The figures reported here are somewhat larger than those gathered by CIAT.

Crop year	HYV area		Proportion of HYV area		
			IR-8	INIAP-6	Total
	Hectares	*Acres*		*Percent*	
1971/72	17,500	43,200	76.9	23.1	100
1972/73	24,200	59,800	48.4	51.6	100
1973/74	61,900	153,000	20.4	79.6	100

In addition, substantial areas are planted to a variety identified only as SML (not a semi-dwarf) and "other" category (which appears to include a small quantity of INIAP-2 (IR-22)). A number of experimental varieties are of IRRI extraction.

El Salvador[19]

The rice area of El Salvador appears to be entirely planted to *improved* varieties. While the area data are available for 11 varieties, none are identified as semi-dwarfs. Some semi-dwarfs (such as CICA-4), however, may be included in the "other" category which accounts for 29 percent of the total area in 1974/75. Also, a variety known as Nilo 11, which is a sister selection of IR-22, has been named in El Salvador but is not specifically listed (a "Selection 11" is listed but has rather low yields). Another semi-dwarf selection (from IR160-27-4) is known as Nilo 9.

Honduras

During 1975, about 6,300 ha. (15,500 acres) of CICA-4 were planted in Honduras. It is expected that a considerable area will be planted to CICA-6 in 1976.[20] Earlier estimates suggested that in 1972/73 about 13 percent of the total rice area, or perhaps 1,700 ha. (4,200 acres) were planted to IR-8 and another variety, thought to be CICA-4.[21]

Mexico

Semi-dwarf rices occupy a significant area in Mexico. Total estimated HYV area is as follows:[22]

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[19] Based on: Foreign Agricultural Service Report ES-4038 from San Salvador, August 1, 1974; letter from James W. Brock, Agricultural Attaché, American Embassy, San Salvador, November 14, 1975; conversation with Peter Jennings, Rockefeller Foundation, New York, January 21, 1976.

[20] Letter from James O. Bleidner, Rural Development Officer, USAID, American Embassy, Tegucigalpa, December 5, 1975.

[21] *CIAT Annual Report, 1972*, p. 160.

[22] Estimates for 1971/72 to 1973/74 provided by Richard A. Smith, Agricultural Attaché, American Embassy, Mexico City, January 14, 1974 (based on data provided

Crop year	HYV area		Proportion of HYV area			
			IR-8	Navaloto A-71[a]	Sinaloa A-68[b]	Total
	Hectares	*Acres*	*Percent*			
1971/72	100,000	247,100	39.5	0.5	60.0	100
1972/73	95,000	234,700	31.6	5.2	63.2	100
1973/74	114,000	281,700	14.5	30.7	54.8	100
1974/75	108,400	267,906	NA	NA	NA	

[a]A sister selection of IR-22.
[b]TN-1 x Nahng Mon S-4.

Clearly the HYV area has been relatively stable. The varietal breakdown for 1974/75 is not yet in hand, but it appears that the proportion of Navaloto A-71 increased substantially while Sinaloa A-68 declined; CICA-4 also was planted in significant quantities in the State of Sinaloa.

Other HYV's mentioned by Mexican breeders include: Joachin A-74, Juchitan A-74, Piedras Negras A-74, Bamoa A-75, Morelos A-70, and Zapata A-70.[23]

Nicaragua[24]

A large portion of the rice area in Nicaragua appears to be planted in the semi-dwarf HYV's. The estimated HYV area in 1974/75 was 20,700 hectares (51,200 acres) or 86 percent of the total rice area. The HYV varietal breakdown was: IR-20, 37.8 percent; IR-100, 34.1 percent; CICA-4, 25.0 percent; and CR-1113, 3.0 percent. (CR-1113 is a selection of IR-822 produced at CIAT; it is a parent of CICA-6.) The remaining 14 percent of the area was planted to improved varieties such as Bluebonnet, Starbonnet, Nilo 1, etc.

Peru

The HYV area in Peru is relatively large and has grown substantially through the early 1970's.[25]

by the Instituto Nacional de Investigaciones Agricolas); 1974/75 estimates from Grant Scobie, CIAT.

[23]Reported by L. Hernandez Aragon, INIA (cited in letter from T. T. Chang, IRRI, March 10, 1976).

[24]Based on: Foreign Agricultural Service Report NC-4018 from San Salvador, August 9, 1974; letter from Armando J. Gonzalez, Agronomist, USAID, American Embassy, Managua, November 4, 1975.

[25]1971/72 estimate derived from *CIAT Annual Report, 1972,* p. 160, 1972/73 to 1974/75 estimates provided by Julio A. Castilla, Agricultural Economist, Office of

Crop year	HYV area		Proportion of HYV area				
			IR-8	Naylamp[a]	Chancay[b]	Huallaga[c]	Total
	Hectares	*Acres*			*Percent*		
1971/72	25,500	65,400	100	—	—	—	100
1972/73	38,300	94,600	81.2	13.6	2.6	2.6	100
1973/74	36,700	90,700	40.6	54.0	2.7	2.7	100
1974/75	62,400	154,000	21.5	71.5	3.5	3.5	100

[a] IR930-2-6.
[b] IR930-31-10.
[c] IR442-2-50.

The estimates reported here are considerably higher than those compiled by Scobie of CIAT (see fn. 1 in this section) on a calendar year basis, possibly because of a difference in classification of HYV's.

Venezuela

The HYV's were first planted on significant areas (30,000 to 40,000 ha. of IR-22 and CICA-4) in Venezuela in 1973.[26] Since then, the estimated area has continued to expand.[27]

Crop year	HYV area		Proportion of HYV area[a]			
			IR-22	CICA-4	CICA-6	Total
	Hectares	*Acres*		*Percent*		
1974/75[b]	104,000	257,000	25.0	62.5	12.5	100
1975/76	120,000	296,500	25.0	50.0	25.0	100

[a] Excludes Llanero 501b, a locally developed variety which is used by smaller producers employing less intensive cultural practices. Perhaps 26,000 ha. (64,200 acres) were planted in 1974/75 and 30,000 ha. (74,100 acres) in 1975/76.
[b] 1,000 M.T. of seed was imported from Colombia in the first quarter of 1975, probably CICA-4 and CICA-6.

The CICA-6 variety appears to be preferred by farmers and its relative importance may increase in the future.

Agricultural Attaché, American Embassy, Lima, November 3, 1975 (data supplied by the Ministry of Food).

[26] Letter from Douglas M. Crawford, Agricultural Attaché, American Embassy, Caracas, November 6, 1973.

[27] Letter from Robert M. McConnell, Agricultural Attaché, American Embassy, Caracas, October 17, 1975 (estimates provided by Dr. Martinez Bello, Director, Seed Experiment Station, Ministry of Agriculture, Marcay).

V. SUMMARY OF ESTIMATED AREA DATA

In this chapter, the time series data reported in the individual country tables for Asia and the Near East for the 1965/66 to 1974/75 period are pulled together in summary form. The chapter basically consists of five tables: the first summarizes the totals by year (also depicted in Summary figure, p. ix); the second summarizes the wheat area by country and year; the third does the same for rice; and the fourth and fifth report HYV area as a proportion of total wheat or rice area.

While some time series data were presented for Latin America, they were neither complete nor consistent enough (especially in terms of the time period) to summarize in the tabular form utilized here. The Latin American data will, however, be briefly noted along with Africa. In any case, all the data are rounded and are to be considered only approximate.

A few comments on the data provided in the five tables (tables 34 through 38) follow. The 2 most recent years reported, 1973/74 and 1974/75, may have been adversely affected by the fertilizer crisis of that period. The data for 1974/75 are preliminary and are subject to revision. In the tables, NA means that the data were not available (at least at the time this report went to press).

TOTAL HYV WHEAT AND RICE AREA

The overall area planted to high-yielding wheat and rice varieties in non-Communist LDC's in Asia and the Near East[1] continued, despite the fertilizer crisis, to expand significantly through 1973/74 and 1974/75 (table 34). Total wheat and rice area was about 32.2 million ha. (79.5 million acres) in 1972/73, 37.9 million ha. (93.7 million acres) in 1973/74, and 40.9 million ha. (101.0 million acres) in 1974/75.[2] The rates of increase for wheat and rice from 1966/67 were remarkably similar (p. ix). For most of this period, the total wheat area slightly exceeded that of rice; in 1973/74, however, the total rice area pulled ahead and stayed there in 1974/75.

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[1] Including South Vietnam but excluding Taiwan.

[2] In making these tabulations, a few countries—for which recent estimates have not been obtained—have been carried at their last recorded level. These are:

Wheat: Algeria, 1972/73; Lebanon, 1972/73, Turkey, 1971/72.

Rice: Laos, 1972/73; Malaysia, 1973/74.

Since the HYV area in each country has probably increased somewhat in subsequent years (except, perhaps, Laos), the process should produce a conservative total figure.

Table 34—Estimated High-yielding Wheat and Rice Area, Asia and Near East, 1965/66 to 1974/75[1]

Crop year	Area		
	Wheat	Rice	Total
		Hectares	
1965/66	9,300	49,400	58,700
1966/67	651,100	1,034,300	1,685,400
1967/68	4,123,400	2,653,500	6,776,900
1968/69	8,012,600	4,707,500	12,720,100
1969/70	8,879,300	7,764,300	16,643,600
1970/71	11,219,700	9,972,100	21,191,800
1971/72	13,930,000	13,052,900	26,982,900
1972/73	16,561,300[2]	15,624,900	32,186,200
1973/74	18,194,100[2,3]	19,715,100[4]	37,909,200
1974/75 (prelim.)	19,288,300[2,3]	21,587,300[4,5]	40,875,600
		Acres	
1965/66	22,900	122,100	145,000
1966/67	1,608,800	2,555,900	4,164,700
1967/68	10,188,800	6,557,000	16,745,800
1968/69	19,799,500	11,631,800	31,431,300
1969/70	21,941,000	19,185,900	41,126,900
1970/71	27,723,900	24,640,900	52,364,800
1971/72	34,421,100	32,254,000	66,675,100
1972/73	40,922,600[2]	38,609,000	79,531,600
1973/74	44,957,700[2,3]	48,716,200[4]	93,673,900
1974/75 (prelim.)	47,661,200[2,3]	53,342,300[4,5]	101,003,500

[1] Excludes Communist countries (except South Vietnam), developed nations, and Taiwan.
[2] Includes Turkey at 1971&72 level.
[3] Includes Algeria and Lebanon at 1972/73 level.
[4] Includes Laos at 1972/73 level.
[5] Includes Malaysia at 1973/74 level.

Of the total HYV area in Asia and the Near East in 1974/75, about 47.2 percent was composed of wheat and 52.8 percent was rice. The total wheat area in 1974/75 was 19.3 million ha. (47.7 million acres) while the rice area was 21.6 million ha. (53.3 million acres). Compared to 1973/74, the 1974/75 wheat area rose 6.0 percent while the rice area climbed 9.5 percent. In 1974/75, about 81.6 percent of the HYV wheat and 99.9 percent of the HYV rice area reported in this section was in Asia; the remainder was in the Near East.

In terms of individual countries, the rate of increase dropped off for some in 1973/74 and 1974/75. In the case of wheat this was most noticeable for India; in the case of rice it was noticeable (in 1974/75) for Bangladesh, Indonesia, and South Vietnam. Levels of HYV use dropped, in 1974/75, for wheat in Morocco and for rice in Sri Lanka. The rate of adoption of HYV wheat in Pakistan began to level out in the early 1970's and has actually dropped since 1971/72 for rice (largely because of price policies).

In terms of overall levels of use of HYV's within Asia and the Near East, India was easily the leader. In 1974/75, it accounted for about 61.1

percent of the total HYV wheat area in Asia and the Near East, and 51.2 percent of the HYV rice area in the same region. In the case of HYV wheat use, India was followed at some distance by Pakistan (19.1 percent). In the case of HYV rice, India was followed by Indonesia (15.9 percent), the Philippines (10.1 percent), and Bangladesh (6.7 percent). All of these countries had over 1 million ha. (2.47 million acres) planted to HYV's in 1974/75. In general, the area of HYV wheat was more concentrated in a few countries than was the case for HYV rice.

In addition to the HYV areas reported for Asia and the Near East, substantial areas were planted in Latin America and a modest area in Africa. The data are too fragmentary, however, to summarize in time series form. While improved wheat varieties of Mexican descent are planted in numerous Latin American nations, as of the mid-1970's, the use of semi-dwarfs was largely concentrated in Argentina and Mexico. The total HYV area in Argentina was quite uncertain but could have been in the millions of hectares; nearly all of the wheat area in Mexico (about 800,000 ha. in 1974/75) continued to be planted to HYV's. Semi-dwarf rice was raised in more Latin American countries, but the total area (excluding Cuba) may have been less—about 770,000 ha. (1.9 million acres). The total area of semi-dwarfs in Africa in 1974/75 was probably about 150,000 ha. (370,000 acres) of wheat and a few thousand hectares of rice.

PROPORTION OF TOTAL AREA PLANTED TO HYV'S

The increases in area planted to HYV's become more meaningful when viewed in terms of the proportion they represent of total wheat or rice area within a given country. To do this properly on an individual country basis, the HYV data cited here should be compared with estimates of total area from the same source for the same season. The compilation of such total area figures, however, was beyond the scope of this study, and a shortcut was utilized: total area data were compiled (with the exception of wheat in Nepal) from periodic reports of the Foreign Agricultural Service of the U.S. Department of Agriculture. This process may have entailed some errors, in part due to timing,[3] but the overall outcome may not be far off. The results are summarized in tables 37 and 38.

Wheat. The level of adoption for wheat as of 1974/75 was quite variable. The highest proportions were found in Nepal (85 percent), Pakistan (62.5 percent), India (62 percent), and Iraq (50 percent). Overall, the adoption rates were considerably higher in South Asia than they were in the Near East, reflecting, in part, an earlier introduction and more irrigation. Over time, the rate of adoption has tended to follow an S-shaped pattern;[4] this is most pronounced in the cases of Pakistan and Iraq. The

[3] The FAS data are reported by calendar year. The following procedure was used to convert other data to a calendar year basis: for wheat, 1972 was recorded as 1971/72; for rice, 1972 was assigned to the 1972/73 crop year.

[4] That is, the rate of adoption starts slowly, then picks up speed, and finally drops off as the innovation is widely used.

Table 35—Estimated Area Planted to High-Yielding Varieties of Wheat in Asia and Near East

	Country	Unit	1965/66	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75 (prelim.)
	ASIA											
1.	Bangladesh	Hectares	–	–	–	8,400	9,100	13,500	15,000	21,450	29,100	33,200
		Acres	–	–	–	20,800	22,500	33,400	37,000	53,000	72,000	82,000
2.	India	Hectares	3,000	540,900	2,942,000	4,792,700	5,004,900	6,542,500	7,858,100	10,007,000	10,911,000	11,778,400
		Acres	7,400	1,336,600	7,269,700	11,842,800	12,367,200	16,166,400	19,417,500	24,727,300	26,961,100	29,104,400
3.	Nepal	Hectares	1,400	6,600	24,800	53,800	75,500	98,200	115,900	170,300	206,800	246,900
		Acres	3,500	16,200	61,300	132,900	186,600	242,700	286,450	420,700	511,000	610,000
4.	Pakistan	Hectares	4,900	101,200	957,100	2,387,700	2,681,500	3,128,300	3,286,200	3,375,200	3,472,300	3,682,800[1]
		Acres	12,000	250,000	2,365,000	5,900,000	6,626,000	7,730,000	8,120,000	8,340,000	8,580,000	9,100,000[1]
	Subtotal	Hectares	9,300	648,700	3,913,900	7,242,600	7,771,000	9,782,500	11,275,200	13,573,950	14,619,200	15,741,300
		Acres	22,900	1,602,800	9,696,000	17,896,500	19,202,300	24,172,500	27,860,950	33,541,000	36,124,100	38,896,400
	NEAR EAST											
5.	Afghanistan	Hectares	–	1,800	22,000	122,000	146,000	232,000	255,000	450,000	475,000	522,000
		Acres	–	4,500	54,400	301,500	360,800	573,200	630,000	1,112,000	1,173,700	1,289,900
6.	Algeria	Hectares	–	–	–	–	5,100	140,000	320,000	600,000	NA	NA
		Acres	–	–	–	–	12,600	346,000	790,700	1,482,600	NA	NA
7.	Egypt	Hectares	–	–	–	–	–	150	1,800	20,100	212,800	78,600
		Acres	–	–	–	–	–	400	4,500	49,700	525,800	194,200
8.	Iran	Hectares	–	–	–	10,000	37,000	63,000	125,000	138,000	261,000[1]	292,500[1]
		Acres	–	–	–	25,000	91,400	155,700	308,900	341,000	644,900[1]	722,800[1]
9.	Iraq	Hectares	–	–	6,400	41,700	195,200	125,000	950,000	595,000	700,000	750,000
		Acres	–	–	15,800	103,000	482,400	309,000	2,347,500	1,470,200	1,729,700	1,853,300
10.	Lebanon	Hectares	–	–	50	400	2,500	7,000	12,000	20,000	NA	NA
		Acres	–	–	120	1,000	6,200	17,300	29,700	49,400	NA	NA
11.	Morocco	Hectares	–	–	200	4,900	46,500	90,000	206,000	294,000	375,100	300,000
		Acres	–	–	500	12,100	114,900	222,400	509,000	726,500	926,900	741,300

Country	Unit	1965/66	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75 (prelim.)
12. Saudi Arabia	Hectares	–	–	–	–	–	–	–	150	2,000	10,000
	Acres	–	–	–	–	–	–	–	350	5,000	24,700
13. Syria	Hectares	–	–	–	–	–	38,000	75,000	121,000	224,000	269,000
	Acres	–	–	–	–	–	94,000	185,300	299,000	553,500	664,700
14. Tunisia	Hectares	–	–	800	12,000	53,000	102,000	60,000	99,000	55,000	54,900
	Acres	–	–	2,000	29,700	131,000	252,000	148,300	244,600	135,900	135,700
15. Turkey	Hectares	–	600	170,000	579,000	623,000	640,000	650,000	NA	NA	NA
	Acres		1,500	420,000	1,430,700	1,539,400	1,581,400	1,606,200	NA	NA	NA
Subtotal	Hectares	–	2,400	199,450	770,000	1,108,300	1,437,150	2,654,800	2,987,250[2]	3,574,900[2,3]	3,547,000[2,3]
	Acres	–	6,000	492,800	1,903,000	2,738,700	3,551,400	6,560,100	7,381,550[2]	8,833,600[2,3]	8,764,800[2,3]
Total Asia & Near East	Hectares	9,300	651,100	4,123,350	8,012,600	8,879,300	11,219,650	13,930,000	16,561,250[2]	18,194,100[2,3]	19,288,300[2,3]
	Acres	22,900	1,608,800	10,188,800	19,799,500	21,941,000	27,723,900	34,421,050	40,922,550[2]	44,957,700[2,3]	47,661,200[2,3]

[1] Unofficial estimate.
[2] Including Turkey at 1971/72 level.
[3] Including Algeria and Lebanon at 1972/73 level.

Table 36—Estimated Area Planted to High-Yielding Varieties of Rice in Asia and the Near East

Country	Unit	1965/66	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75 (prelim.)
ASIA											
1. Bangladesh	Hectares	–	200	67,200	154,200	263,900	460,100	623,600	1,064,400	1,584,800	1,443,600
	Acres	–	500	166,000	381,000	652,000	1,137,000	1,541,000	2,630,000	3,827,000	3,567,000
2. Burma	Hectares	–	–	3,400	166,900	143,000	190,900	185,100	199,200	252,600	332,200
	Acres	–	–	8,500	412,400	353,300	471,800	457,300	492,200	624,200	820,900
3. India	Hectares	7,100	888,400	1,785,000	2,681,000	4,253,600	5,454,000	7,199,400	8,107,400	9,718,200	11,045,200
	Acres	17,650	2,195,200	4,410,700	6,624,800	10,510,500	13,476,700	17,789,800	20,033,400	24,013,700	27,292,700
4. Indonesia	Hectares	–	–	–	198,000	831,000	902,600	1,332,900	1,928,000	3,100,800	3,440,000
	Acres	–	–	–	489,000	2,054,000	2,230,400	3,293,700	4,764,200	7,662,000	8,500,200
5. Korea	Hectares	–	–	–	–	–	–	2,700	187,500	139,000	306,900
(South)	Acres	–	–	–	–	–	–	6,700	463,300	343,500	758,300
6. Laos	Hectares	–	360	1,200	2,000	2,000	53,600	30,000	50,000	NA	NA
	Acres	–	900	3,000	5,000	5,000	132,500	74,100	123,600	NA	NA
7. Malaysia	Hectares	42,300	62,700	90,700	96,100	132,400	164,600	197,400	212,200	217,000	NA
(West)	Acres	104,450	155,000	224,200	237,500	327,100	406,600	487,900	524,400	536,300	NA
8. Nepal	Hectares	–	–	–	42,500	49,800	67,800	81,600	177,300	205,100	222,600
	Acres	–	–	–	105,100	123,000	167,600	201,700	438,000	506,800	550,100
9. Pakistan	Hectares	–	80	4,000	308,000	501,400	550,400	728,500	647,100	636,600	630,900
	Acres	–	200	10,000	761,000	1,239,000	1,360,000	1,800,000	1,599,000	1,573,000	1,559,000
10. Philippines	Hectares	–	82,600	701,500	1,011,800[1]	1,353,900	1,565,400	1,826,800	1,679,900	2,176,600	2,175,000
	Acres	–	204,100	1,733,400	2,500,000[1]	3,345,500	3,868,100	4,514,000	4,151,000	5,378,400	5,374,400
11. Sri Lanka	Hectares	–	–	–	7,000	26,300	30,700	70,900	231,900	368,400	352,100
	Acres	–	–	–	17,200	65,100	75,800	175,300	572,900	910,400	870,000
12. Thailand	Hectares[1]	–	–	–	–	3,000	30,000	100,000	300,000	400,000	450,000
	Acres[1]	–	–	–	–	7,400	74,000	247,100	741,300	988,400	1,112,000
13. Vietnam	Hectares	–	–	500	40,000	204,000	502,000	674,000	835,000	890,000	900,000[1]
(South)	Acres	–	–	1,200	98,800	504,000	1,240,400	1,665,400	2,063,300	2,199,200	2,223,900[1]
Subtotal	Hectares	49,400	1,034,300	2,653,500	4,707,500	7,764,300	9,972,100	13,052,900	15,619,900	19,703,100[2]	21,565,500[2,3]
	Acres	122,100	2,555,900	6,557,000	11,631,800	19,185,900	24,640,900	32,254,000	38,596,600	48,686,500[2]	53,288,400[2,3]

	Country	Unit	1965/66	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75 (prelim.)
	NEAR EAST											
14.	Egypt	Hectares	–	–	–	–	–	–	–	–	NA	6,800
		Acres	–	–	–	–	–	–	–	–	NA	16,800
15.	Iraq	Hectares	–	–	–	–	–	–	–	5,000	12,000	15,000
		Acres	–	–	–	–	–	–	–	12,400	29,700	37,100
	Subtotal	Hectares	–	–	–	–	–	–	–	5,000	12,000	21,800
		Acres	–	–	–	–	–	–	–	12,400	29,700	53,900
	Total Asia and Near East	Hectares	49,400	1,034,300	2,653,500	4,707,500	7,764,300	9,972,100	13,052,900	15,624,900	19,715,100[2]	21,587,300[2,3]
		Acres	122,100	2,555,900	6,557,000	11,631,800	19,185,900	24,640,900	32,254,000	38,609,000	48,716,200[2]	53,342,300[2,3]

[1] Unofficial Estimate.
[2] Including Laos at 1972/73 level.
[3] Including Malaysia at 1973/74 level.

Table 37—Proportion of Total Wheat Area Planted to High-Yielding Varieties, Asia and the Near East

Country	Crop Year									
	1965/66	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75 (prelim.)
	Percent									
ASIA										
1. Bangladesh	–	–	–	7.2	7.6	11.3	11.8	17.7	23.1	23.4
2. India	negl.	4.2	19.6	30.0	30.1	35.9	41.1	51.4	57.4	61.7
3. Nepal	1.2	5.2	12.9	25.9	33.5	43.0	52.3	65.6	75.5	84.9
4. Pakistan	0.1	1.9	16.0	38.0	43.0	52.3	56.7	56.5	59.0	62.5[1]
NEAR EAST										
5. Afghanistan	–	negl.	0.8	4.3	5.1	9.2	10.1	15.0	16.1	17.4
6. Algeria	–	–	–	–	2.2	6.7	14.5	27.9	NA	NA
7. Egypt	–	–	–	–	–	negl.	0.3	3.5	39.8	14.3
8. Iran	–	–	–	0.2	0.9	1.6	2.9	3.2	6.1[1]	6.7[1]
9. Iraq	–	–	0.3	2.0	9.6	9.0	45.2	49.6	42.9	50.0
10. Lebanon	–	–	negl.	0.7	4.1	11.7	18.8	31.3	NA	NA
11. Morocco	–	–	negl.	0.3	2.5	4.8	10.0	14.4	19.6	16.7
12. Saudi Arabia	–	–	–	–	–	–	–	negl.	2.0	10.0
13. Syria	–	–	–	–	–	4.3	6.8	10.1	14.9	17.0
14. Tunisia	–	–	0.1	1.8	7.1	10.7	6.0	9.4	5.5	5.5
15. Turkey	–	negl.	2.1	7.0	7.6	7.8	8.0	NA	NA	NA

[1] Based on unofficial estimates of HYV area.

Table 38—Proportion of Total Rice Area Planted to High-Yielding Varieties, Asia and the Near East

Country	Crop Year									
	1965/66	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75 (prelim.)
	Percent									
ASIA										
1. Bangladesh	—	negl.	0.7	1.6	2.6	4.6	6.7	11.1	15.6	14.9
2. Burma	—	—	negl.	3.3	2.9	2.6	3.6	4.2	5.1	6.4
3. India	negl.	2.5	4.9	7.3	11.3	14.6	19.3	23.2	25.6	29.9
4. Indonesia	—	—	—	2.4	10.4	11.0	15,8	22.8	36.6	40.3
5. Korea (South)	—	—	—	—	—	—	0.2	15.6	11.7	25.5
6. Laos	—	negl.	0.2	0.3	0.2	6.0	3.3	5.5	NA	NA
7. Malaysia	10.0	14.7	20.6	20.1	26.4	30.9	35.8	37.1	36.7	NA
8. Nepal	—	—	—	3.7	4.4	5.8	6.3	14.8	17.1	18.6
9. Pakistan	—	negl.	0.3	19.8	29.9	36.6	50.0	43.7	42.1	40.3
10. Philippines	—	2.7	21.2	30.4[1]	43.5	50.3	56.3	54.0	63.4	64.0
11. Sri Lanka	—	—	—	1.0	3.9	4.6	10.6	33.2	64.5	52.8
12. Thailand[1]	—	—	—	—	negl.	0.4	1.3	4.2	5.0	5.5
13. Vietnam (South)	—	—	negl.	1.6	8.3	19.9	25.9	32.1	31.1	29.9[1]
NEAR EAST										
14. Egypt	—	—	—	—	—	—	—	—	negl.	0.1
15. Iraq	—	—	—	—	—	—	—	5.0	12.6	15.8

[1] Based on unofficial estimates of HYV area.

pattern of adoption is somewhat more variable in the Near East countries than in South Asia. Two Near East nations, Tunisia and Turkey, show little change in proportion of area. Others, such as Saudi Arabia, are in the early stages of adoption and the rate is still on the increase.

Rice. The rate of adoption for HYV rices was also quite variable among individual LDC's. The highest rates in 1974/75 were found in: the Philippines (64 percent), Sri Lanka (53 percent), and Pakistan and Indonesia (40 percent). Over time, the rate of adoption has also tended to follow an S-shaped pattern, with several exceptions. In Pakistan and Vietnam the proportion has dropped somewhat since 1971/72; in India the trend was still up in 1974/75 (this was also true in several countries such as Korea which adopted the HYV's more recently).

All told, the HYV's of wheat and rice represented the following proportion of total area in each region (excluding Communist nations and developed countries) in 1974/75:

Region	Wheat	Rice
	Percent	
Asia (South & East)	61.7	26.4
Near East (West Asia & North Africa)	14.3	1.8
Total Asia & Near East	38.4	26.0

Clearly, the adoption levels for HYV wheat and rice are much higher in Asia than in the Near East. Moreover, the overall adoption level for wheat is greater than for rice.

In addition to these regions, it might be noted that HYV wheats represent a large portion of the wheat area in Mexico, Guatemala, and perhaps Argentina. HYV rice varieties also represent large proportions of total area in Colombia, Costa Rica, Cuba, Nicaragua, and Peru. HYV proportions in Africa south of the Mediterranean countries are low.

Countries with current high levels of adoption are likely to face slower rates of expansion of HYV area in the future. Some nations are probably well along the adoption curve or approaching the top. For most major countries, moreover, the top of the curve for HYV's may be considerably below 100 percent. Several supply and demand factors constrain adoption. On the supply side, we have noted (1) that the present HYV's are not suitable for all soil and climate conditions and, (2) that they require seeds and inputs which are either not available or not utilized by every farmer. The fertilizer shortage which emerged in 1973 and 1974 probably slowed the rate of adoption. On the demand side, the HYV's do not meet all consumer requirements. In many areas, for example, there are long-established tastes for certain types and kinds of grains which are not satisfied by the present HYV's. Because of these and other factors, the HYV's are unlikely to completely replace traditional varieties in most major areas in the near future.

Even if HYV adoption levels begin to taper off, however, this does not mean that yield levels will have to stagnate. New HYV's, with greater yield

potential and/or stability, are constantly being developed. The use of other production inputs, such as fertilizer, is generally low and considerable increase is possible. Further improvements in other cultural practices are also possible. Thus considerable potential for yield increases remains even after the HYV adoption curve levels off.

VI. APPENDIX

A. PUBLICATIONS ON ECONOMIC AND SOCIAL EFFECTS OF THE GREEN REVOLUTION

There has been a vast outpouring of reports on the green revolution. The following publications are particularly useful:

Dana G. Dalrymple, *Technological Change in Agriculture: Effects and Implications for the Developing Nations,* U.S. Department of Agriculture, Foreign Agricultural Service, April 1969, 82 pp.; Clifton R. Wharton Jr., "The Green Revolution: Cornucopia or Pandora's Box?" *Foreign Affairs*, April 1969, pp. 472-473; Joseph W. Willett, *The Impact of New Grain Varieties in Asia,* U.S. Department of Agriculture, Economic Research Service, ERS-Foreign 275, July 1969, 26 pp.; Lester R. Brown, *Seeds of Change,* Praeger, 1970, 205 pp.; Walter P. Falcon, "The Green Revolution: Generations of Problems," *American Journal of Agricultural Economics,* December 1970, pp. 698-710; F. F. Hill and Lowell S. Hardin, "Crop Production Successes and Emerging Problems in Developing Countries," in *Some Issues Emerging from Recent Breakthroughs in Food Production* (ed. by K. L. Turk), New York State College of Agriculture, Cornell University, 1971 pp. 3-29; Francine R. Frankel, *India's Green Revolution: Economic Gains and Political Costs,* Princeton University Press, 1971, 232 pp.; Zubeida M. Ahmad, "The Social and Economic Implications of the Green Revolution in Asia," *International Labor Review,* January 1972, pp. 9-34; Randolph Barker, "The Economic Consequences of the Green Revolution in Asia," in *Rice, Science, and Man,* International Rice Research Institute, April 1972, pp. 115-126; Clive Bell, "The Acquisition of Agricultural Technology: Its Determinants and Effects," *The Journal of Development Studies,* October 1972, pp. 123-159; T. T. Poleman and D. K. Freebairn (eds.), *Food, Population and Employment: The Impact of the Green Revolution,* Praeger 1973, 272 pp.; Robert Evenson, "The Green Revolution in Recent Development Experience," *American Journal of Agricultural Economics,* May 1974, pp. 387-394; Keith Griffin, *The Political Economy of Agrarian Change; An Essay on the Green Revolution,* Harvard University Press, Cambridge, 1974, 264 pp.; *The Social and Economic Implications of Large-Scale Introduction of New Varieties of Foodgrains,* United Nations Research Institute for Social Development (Geneva), 1974, 55 pp.; Nicolas Wade, "Green Revolution," *Science,* December 20, 1974, pp. 1093-1096, December 27, 1974, pp. 1186-1192; Gelia T. Castillo, *All in a Grain of Rice,* Southeast Asian Regional Center for Graduate Study and Research in Agriculture (Laguna), 1975, 410 pp.; V. S. Vyas, *India's High-Yielding Varieties Programme in Wheat, 1966-67 to 1971-72,* CIMMYT, 1975, 35 pp.

B. THE DEVELOPMENT OF FLORENCE X AURORE WHEAT[1]

Florence x Aurore has long been one of the leading improved wheat varieties in North Africa. It played a role in the early Mexican breeding program (see Chapter II) and has served as a parent for numerous other improved varieties. Yet its origins have been obscure. Since it represents one of the better improved varieties, it may be useful briefly trace its origin and development.

Florence x Aurore was the result of a cross between two Australian varieties, Florence and Aurore, made in 1920 by Emile Schribeaux of the Station d'Essais de Semences of the Institut National Agronomique in Paris.

Florence, in turn, represented a Australian cross made by William J. Farrar in 1901 (and named in 1906) between two unnamed varieties descended from White Naples,[2] Improved Fife,[3] and Eden (Fulcaster). Florence was widely planted in Australia and was also grown in other countries.[4]

Aurore was also an Australian cross, made by Farrar, between Jacinth (from A. E. Blount, Colorado[5]) and Ladoga (a well-known spring red wheat of Russian origin[6]).[7] It was developed by Henry de Vilmorin in France.

Florence x Aurore was one of a packet of 19 F_2 generation varieties of seeds sent to Dr. F. Boeuf in Tunisia by Dr. Schribeaux on December 2, 1922.[8] It was released for general cultivation in 1930/31 and is still widely

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[1] Based, except as noted, on letters and materials from: P. Auriau, Station Centrale de Génétique et d'Amélioration des Plantes, CNRA, Versailles, September 10, 1975, January 6, 1976; N. H. Luig, Plant Breeding Institute, University of Sydney, Castle Hill, New South Wales, October 1, 1975, January 5, 1976.

[2] "Richelle Blanche de Naples." Provided by Vilmorin. Described in *Les Meilleurs Blés,* Vilmorin-Andrieux, Paris, 1880, p. 44. Also see S. L. Macindoe and C. W. Brown, *Wheat Breeding and Varieties in Australia,* Department of Agriculture, New South Wales, Sydney, Science Bulletin No. 76, 1968 (3rd ed.), p. 216.

[3] A white-grained selection from Red Fife made by A. E. Blount of Colorado State University (Macindoe and Brown, *op. cit.*, p. 141).

[4] For background information on Farrar and Florence, see: J. Allen Clark, "Improvement in Wheat," *Yearbook of Agriculture, 1936* (USDA), pp. 239–240; and H. Wenholz, *The Improvement of Australian Wheat; Milestones in its Progress,* Department of Agriculture, New South Wales, Sydney, 1937, pp. 1–3.

[5] Possibly a selection from Fife. According to Clark (*op. cit.*, p. 222): "A. E. Blount at the Colorado Agricultural Experiment Station was among the first to breed varieties of hybridization. Several of his wheats were sent to Farrar of New South Wales, and these entered into the parentage of some of Farrar's best wheats." No mention of Jacinth, however, has been found in USDA or Colorado State University files.

[6] See, for example, J. A. Clark and B. B. Bayles, *Classification of Wheat Varieties Grown in the United States in 1939,* U.S. Department of Agriculture, Technical Bulletin No. 795, June 1942, p. 116.

[7] Macindoe and Brown, *op. cit.*, pp. 57, 142.

[8] Dr. Auriau kindly provided a copy of Schribeaux's cover letter and a list of the other 18 varieties. Also see F. Boeuf, "Le Blé en Tunisie," *Annals du Service Botanique et Agronomique,* Tunis, Tome VIII, 1932, pp. 60–61.

grown. Florence x Aurore, under the name Marroqui, was used in the early Mexican breeding work.[9]

Lines subsequently selected from Florence x Aurore in Tunisia include Ariana 8 and Koudiat 17. Lines selected elsewhere include: 8193 in Algeria, 2511 in Morocco, and Blé d'Avril in France. A Florence x Aurore strain, selected in 1925, is known as Cailloux (registered in Tunisia as No. 588). Florence Aurore is also included in the parentage of a number of varieties, including Karaj 2 in Iran and Lakehish in Israel.

[9] Norman E. Borlaug, "Wheat Breeding and Its Impact on World Food Supply," *Proceedings of the Third International Wheat Genetics Symposium*, Canberra, 1968, p. 5.

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